SCIENCE

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SYLVESTER.

ON Monday, March 15, 1897, in London, where, September 3, 1814, he was born, died the most extraordinary personage for half a century in the mathematical world.

James Joseph Sylvester was second wrangler at Cambridge in 1837. When we recall that Sylvester, Wm. Thomson, Maxwell, Clifford, J. J. Thomson were all second wranglers, we involuntarily wonder if any senior wrangler except Cayley can be ranked with them.

Yet it was characteristic of Sylvester that not to have been first was always bitter to him.

The man who beat him, Wm. N. Griffin, also a Johnian, afterwards a modest clergyman, was tremendously impressed by Sylvester, and honored him in a treatise on optics where he used Sylvester's first published paper, 'Analytical development of Fresnel's optical theory of crystals,' *Philosophical Magazine*, 1837.

Sylvester could not be equally generous, and explicitly rated above Griffin the fourth wrangler George Green, justly celebrated, who died in 1841.

Sylvester's second paper, 'On the motion and rest of fluids,' *Phil. Mag.*, 1838 and 1839, also seemed to point to physics.

In 1838 he succeeded the Rev. Wm. Ritchie as professor of natural philosophy in University College, London.

His unwillingness to submit to the re-

ligious tests then enforced at Cambridge and to sign the 39 articles not only debarred him from his degree and from competing for the Smith's prizes, but, what was far worse, deprived him of the Fellowship morally his due. He keenly felt the injustice.

In his celebrated address at the Johns Hopkins University his denunciation of the narrowness, bigotry and intense selfishness exhibited in these compulsory creed tests, made a wonderful burst of oratory. These opinions were fully shared by De Morgan, his colleague at University College. Copies I possess of the five examination papers set by Sylvester at the June examination, session of 1839–40, show him striving as a physicist, but it was all a false start. Even his first paper shows he was always the Sylvester we knew. To the 'Index of Contents' he appends the characteristic note: "Since writing this index I have made many additions more interesting than any of the propositions here cited, which will appear toward the conclusion." Ever he is borne along helpless but ecstatic in the ungovernable flood of his thought.

A physical experiment never suggests itself to the great mental experimenter. Cayley once asked for his box of drawing instruments. Sylvester answered, "I never had one." Something of this irksomeness of the outside world, the world of matter, may have made him accept, in 1841, the professorship offered him in the University of Virginia.

On his way to America he visited Rowan Hamilton at Dublin in that observatory where the maker of quaternions was as out of place as Sylvester himself would have been. The Virginians so utterly failed to understand Sylvester, his character, his aspirations, his powers, that the Rev. Dr. Dabney, of Virginia, has seriously assured me that Sylvester was actually deficient in intellect, a sort of semi-idiotic calculating boy. For the sake of the contrast, and to show the sort of civilization in which this genius had risked himself, two letters from Sylvester's tutors at Cambridge may here be of interest.

The great Colenso, Bishop of Natal, previously Fellow and Tutor of St. John's College, writes: "Having been informed that my friend and former pupil, Mr. J. J. Sylvester, is a candidate for the office of professor of mathematics, I beg to state my high opinion of his character both as a mathematician and a gentleman.

"On the former point, indeed, his degree of Second Wrangler at the University of Cambridge would be, in itself, a sufficient testimonial. But I beg to add that his powers are of a far higher order than even that degree would certify."

Philip Kelland, himself a Senior Wrangler, and then professor of mathematics in the University of Edinburgh, writes: "I have been requested to express my opinion of the qualifications of Mr. J. J. Sylvester, as a mathematician."

"Mr. Sylvester was one of my private pupils in the University of Cambridge, where he took the degree of Second Wrangler. My opinion of Mr. Sylvester then was that in originality of thought and acuteness of perception he had never been surpassed, and I predicted for him an eminent position among the mathematicians of Europe. My anticipations have been verified. Mr. Sylvester's published papers manifest a depth and originality which entitles them to the high position they occupy in the field of scientific discovery. They prove him to be a man able to grapple with the most difficult mathematical questions and are satisfactory evidence of the extent of his attainments and the vigor of his mental powers."

The five papers produced in this year, 1841, before Sylvester's departure for Virginia, show that now his key-note is really struck. They adumbrate some of his greatest discoveries.

They are: 'On the relation of Sturm's auxiliary functions to the roots of an algebraic equation,' British Assoc. Rep. (pt. 2), 1841; 'Examples of the dialytic method of elimination as applied to ternary systems of equations,' Camb. M. Jour. II., 1841; 'On the amount and distribution of multiplicity in an algebraic equation,' Phil. Mag. XVII., 1841; 'On a new and more general theory of multiple roots,' Phil. Mag. XVIII., 1841; 'On a linear method of eliminating between double, treble and other systems of algebraic equations,' Phil. Mag. XVIII., 1841; 'On the dialytic method of elimination,' Phil. Mag. XXI., Irish Acad. Proc. II.

This was left behind in Ireland, on the way to Virginia. Then suddenly occurs a complete stoppage in this wonderful productivity. Not one paper, not one word, is dated from the University of Virginia. Not until 1844 does the wounded bird begin again feebly to chirp, and indeed it is a whole decade before the song pours forth again with mellow vigor that wins a waiting world.

Disheartening was the whole experience; but the final cause of his sudden abandonment of the University of Virginia I gave in an address entitled 'Original Research and Creative Authorship the Essence of University Teaching,' printed in SCIENCE, N. S., Vol. I., pp. 203–7, February 22, 1895.

On the return to England with heavy heart and dampened ardor he takes up for his support the work of an actuary and then begins the study of law. In 1847 we find him at 26 Lincoln's Inn Fields, 'eating his terms.' On November 22, 1850, he is called to the bar and practices conveyancing.

But already in his paper dated August 12, 1850, we meet the significant names Boole, Cayley, and harvest is at hand.

The very words which must now be used to say what had already happened and what was now to happen were not then in existence. They were afterward made by Sylvester and constitute in themselves a tremendous contribution. As he himself says: "Names are, of course, all important to the progress of thought, and the invention of a really good name, of which the want, not previously perceived, is recognized, when supplied, as having ought to be felt, is entitled to rank on a level in importance with the discovery of a new scientific theory."

Elsewhere he says of himself: "Perhaps I may without immodesty lay claim to the appellation of the Mathematical Adam, as I believe that I have given more names (passed into general circulation) to the creatures of the mathematical reason than all the other mathematicians of the age combined."

In one year, 1851, Sylvester created a whole new continent, a new world in the universe of mathematics. Demonstration of its creation is given by the Glossary of new Terms which he gives in the *Philosophical Transactions*, Vol. 143, pp. 543–548.

Says Dr. W. Franz Meyer in his exceedingly valuable Bericht über die Fortschritte der projectiven Invariantentheorie, the best history of the subject (1892):

"Als äusseres Zeichen für den Umfang der vorgeschrittenen Entwickelung mag die ausgedehnte, grösstenteils von *Sylvester* selbst herrührende Terminologie dienen, die sich am Ende seiner grossen Abhandlung über Sturm'sche Functionen (1853) zusammengestellt findet."

Using then this new language, let us briefly say what had happened in the decade when Sylvester's genius was suffering from its Virginia wound. The birth-day of the giant *Theory of Invariants* is April 28, 1841, the date attached by George Boole to a paper in the Cambridge *Mathematical Journal* where he not only proved the invariantive property of discriminants generally, but also gave a simple principle to

form simultaneous invariants of a system of two functions. The paper appeared in November, 1841, and shortly after, in February, 1842, Boole showed that the polars of a Form lead to a broad class of covariants. Here he extended the results of the first article to more than two Forms. Boole's papers led Cayley, nearly three years later (1845), to propose to himself the problem to determine *a priori* what functions of the coefficients of an equation possess this property of invariance, and he discovered its possession by other functions besides discriminants, for example the quadrinvariants of binary quantics, and in particular the invariant S of a quartic.

Boole next discovered the other invariant T of a quartic and the expression of the discriminant in terms of S and T. Cayley next (1846) published a symbolic method of finding invariants. Early in 1851 Boole reproduced, with additions, his paper on Linear Transformations; then at last began Sylvester. He always mourned what he called 'the years he lost fighting the world'; but, after all, it was he who made the Theory of Invariants.

Says Meyer: "sehen wir in dem Cyklus *Sylvester*'scher Publicationen (1851–1854) bereits die Grundzüge einer allgemeinen Theorie erstehen, welche die Elemente von den verschiedenartigsten Zweigen der späteren Disciplin umfasst." "Sylvester beginnt damit, die Ergebnisse seiner Vorgänger unter einem einzigen Gesichtspunkte zuvereinigen."

With deepest foresight Sylvester introduced, together with the original variables, those dual to them, and created the theory of contravariants and intermediate forms. He introduced, with many other processes for producing invariantive forms, the principle of mutual differentiation.

Hilbert attributes the sudden growth of the theory to these processes for producing and handling invariantive creatures. "Die Theorie dieser Gebilde erhob sich, von speciellen Aufgaben ausgehend, rasch zu grosser Allgemeinheit—dank vor Allem dem Umstande, dass es gelang, eine Reihe von besonderen der Invariantentheorie eigenthümlichen Prozessen zu entdecken, deren Anwendung die Aufstellung und Behandlung invarianter Bildungen beträchtlich erleichterte."

"Was die Theorie der algebraischen Invarianten anbetrifft so sind die ersten Begründer derselben, *Cayley* und *Sylvester*, zugleich auch als die Vertreter der naiven Periode anzusehen: an der Aufstellung der einfachsten Invariantenbildungen und an den eleganten Anwendungen auf die Auflösung der Gleichungen der ersten 4 Grade hatten sie die unmittelbare Freude der ersten Entdeckung." It was Sylvester alone who created the theory of canonic forms and proceeded to apply it with astonishing power. What marvelous mass of brand new being he now brought forth!

Moreover he trumpeted abroad the eruption. He called for communications to himself in English, French, Italian, Latin or German, so only the 'Latin character' were used.

From 1851 to 1854 he produces forty-six different memoirs. Then comes a dead silence of a whole year, broken in 1856 by a feeble chirp called 'A Trifle on Projectiles."

What has happened? Some more 'fighting the world.' Sylvester declared himself a candidate for the vacant professorship of geometry in Gresham College, delivered a probationary lecture on the 4th of December, 1854, and was ignominiously 'turned down.' Let us save a couple of sentences from this lecture:

"He who would know what geometry is must venture boldly into its depths and learn to think and feel as a geometer. I believe that it is impossible to do this, to study geometry as it admits of being stud-

ied, and I am conscious it can be taught, without finding the reasoning invigorated, the invention quickened, the sentiment of the orderly and beautiful awakened and enhanced, and reverence for truth, the foundation of all integrity of character, converted into a fixed principle of the mental and moral constitution, according to the old and expressive adage '*abeunt studia in mores.*'"

But this silent year concealed still another stunning blow of precisely the same sort, as bears witness the following letter from Lord Brougham to The Lord Panmure:

"BROUGHAM,

PRIVATE. 28 Aug. 1855.

MY DEAR P.

My learned excellent friend and brother mathematician Mr. Sylvester is again a candidate for the professorship at Woolwich on the death of Mr. O'Brian who carried it against him last year.

I entreat once more your favorable consideration of this eminent man who has already to thank you for your great kindness.

Yours sincerely

H. BROUGHAM.

On this third trial, backed by such an array of credentials as no man ever presented before, he barely scraped through, was appointed professor of mathematics at the Royal Military Academy, and served at Woolwich exactly 14 years, 10 months and 15 days.

A single sentence of his will best express his greatest achievement there and his manner of exit thence:

"If Her Most Gracious Majesty should ever be moved to recognize the palmary exploit of the writer of this note in the field of English science as having been the one successfully to resolve a question and conquer an algebraical difficulty which had exercised in vain for two centuries past, since the time of Newton, the highest mathematical intellects in Europe (Euler Lagrange, Maclaurin, Waring among the number), by conferring upon him some honorary distinction in commemoration of the deed, he will crave the privilege of being allowed to enter the royal presence, not covered, like De Courcy, but barefooted, with rope around his waist, and a *goose*-quill behind his ear, in token of repentant humility, and as an emblem of convicted simplicity in having once supposed that on such kind of success he could found any additional title to receive fair and just consideration at the hands of Her Majesty's Government when quitting his appointment as public professor at Woolwich under the coercive operation of a non-Parliamentary retrospective and utterly unprecedented War Office enactment." Athenæum Club, January 31, 1871. Of course this means a row of barren years, 1870, 1871, 1872, 1873.

The fortunate accident of a visit paid Sylvester in the autumn of 1873 by Pafnuti Lvovich Chebyshev, of the University of St. Petersburg, reawakened our genius to produce in a single burst of enthusiasm a new branch of science.

On Friday evening, January 23, 1874, Sylvester delivered at the Royal Institution a lecture entitled 'On Recent Discoveries in Mechanical Conversion of Motion," whose ideas, carried on by two of his hearers, H. Hart and A. B. Kempe, have made themselves a permanent place even in the elements of geometry and kinematics. A synopsis of this lecture was published, but so curtailed and twisted into the third person that the life and flavor are quite gone from it. I possess the unique manuscript of this epoch-making lecture as actually delivered. A few sentences will show how characteristic and inimitable was the original form:

"The air of Russia seems no less favorable to mathematical acumen than to a genius for fable and song. Lobacheffsky, the first to mitigate the severity of the Euclidean code and to beat down the bars

of a supposed adamantine necessity, was born (a Russian of Russians), in the government of Nijni Novgorod; Tchebicheff [Chebyshev], the prince and conqueror of prime numbers, able to cope with their refractory character and to confine the stream of their erratic flow, their progression, within algebraic limits, in the adjacent circumscription of Moscow; and our own Cayley was cradled amidst the snows of St. Petersburg." [Sylvester himself contracted Chebyshev's limits for the distribution of primes.] "I think I may fairly affirm that a simple direct solution of the problem of the duplication of the cube by mechanical means was never accomplished down to this day. I will not say but that, by a merciful interpretation of his oracle, Apollo may have put up with the solution which the ancient geometers obtained by means of drawing two parabolic curves; but of this I feel assured that had I been then alive, and could have shown my solution, which I am about to exhibit to you, Apollo would have leaped for joy and danced (like David before the ark), with my triple cell in hand, in place of his lyre, before his own duplicated altar."

That in the very next year Sylvester was taking a more active part than has hitherto been known in the organization of the incipient Johns Hopkins University is seen from the following letter to him in London from the great Joseph Henry:

Smithsonian Institution,
August 25, 1875.

My Dear Sir:

Your letter of the 13th inst. has just been received and in reply I have to say that I have written to President Gilman of the Hopkins University giving my views as to what it ought to be and have stated that if properly managed it may do more for the advance of literature and science in this country than any other institution ever established; it is entirely independent of public favor and may lead instead of following popular opinion.

I have advised that liberal salaries be paid to the occupants of the principal chairs and that to fill them the best men in the world who can be obtained should be secured.

I have mentioned your name prominently as one of the very first mathematicians of the day; what the result will be, however, I can not say.

The Trustees are all citizens of Baltimore and among them I have some personal friends; the President, Mr. Gilman, and one of them, came to Washington a few weeks ago to get from me any suggestions that I might have to offer.

It is to be regretted that in this country the Trustees, who control the management of bequests of this character, think it important to produce a palpable manifestation of of the institution to be established by spending a large amount of the bequest in architectural displays. Against this custom I have protested and have asserted that if the proper men and the necessary implements of instruction are provided, the teaching may be done in log cabins.

It would give me great pleasure to have you again as my guest, and I will do what I can to secure your election. Very truly your friend,

Joseph Henry.

We know the result.

Sylvester was offered the place; demanded a higher salary; won; came.

I was his first pupil, his first class, and he always insisted that it was I who brought him back to the Theory of Invariative Forms. In a letter to me of September 24, 1882, he writes: "Nor can I ever be oblivious of the advantage which I derived from your well-grounded persistence in inducing me to lecture on the Modern Algebra, which had the effect of bringing my mind back to this subject, from which it had for some time previously been withdrawn, and in which I have been laboring, with a success which has considerably exceeded my anticipations, ever since."

He made this same statement at greater length in his celebrated address at the Johns Hopkins on February 22, 1877: "At this moment I happen to be engaged in a research of fascinating interest to myself, and which, if the day only responds to the promise of its dawn, will meet, I believe, a sympathetic response from the professors of our divine algebraical art wherever scattered through the world.

"There are things called Algebraical Forms; Professor Cayley calls them Quantics. These are not, properly speaking, Geometrical Forms, although capable, to some extent, of being embodied in them, but rather schemes of processes, or of operations for forming, for calling into existence, as it were, algebraic quantities.

"To every such Quantic is associated an infinite variety of other forms that may be regarded as engendered from and floating, like an atmosphere, around it; but infinite in number as are these derived existences, these emanations from the parent form, it is found that they admit of being obtained by composition, by mixture, so to say, of a certain limited number of fundamental forms, standard rays, as they might be termed, in the Algebraic Spectrum of the Quantic to which they belong; and, as it is a leading pursuit of the physicists of the present day to ascertain the fixed lines in the spectrum of every chemical substance, so it is the aim and object of a great school of mathematicians to make out the fundamental derived forms, the Covariants and Invariants, as they are called, of these Quantics.

"This is the kind of investigation in which I have, for the last month or two, been immersed, and which I entertain great hopes of bringing to a successful issue.

"Why do I mention it here? It is to illustrate my opinion as to the invaluable aid of teaching to the teacher, in throwing him back upon his own thoughts and leading him to evolve new results from ideas that would have otherwise remained passive or dormant in his mind.

"But for the persistence of a student of this university in urging upon me his desire to study with me the modern algebra I should never have been led into this investigation; and the new facts and principles which I have discovered in regard to it (important facts, I believe) would, so far as I am concerned, have remained still hidden in the womb of time. In vain I represented to this inquisitive student that he would do better to take up some other subject lying less off the beaten track of study, such as the higher parts of the Calculus or Elliptic Functions, or the theory of Substitutions, or I wot not what besides. He stuck with perfect respectfulness, but with invincible pertinacity, to his point. He would have the New Algebra (Heaven knows where he had heard about it, for it is almost unknown on this continent), that or nothing. I was obliged to yield, and what was the consequence? In trying to throw light upon an obscure explanation in our text-book my brain took fire; I plunged with requickened zeal into a subject which I had for years abandoned, and found food for thoughts which have engaged my attention for a considerable time past, and will probably occupy all my powers of contemplation advantageously for several months to come."

Another specific instance of the same thing he mentions in his paper, 'Proof of the Hitherto Undemonstrated Fundamental Theorem of Invariants,' dated November 13, 1877:

"I am about to demonstrate a theorem which has been waiting proof for the last quarter of a century and upwards. It is the more necessary that this should be done, because the theorem has been supposed to lead to false conclusions, and its correctness has consequently been impugned. Thus in Professor Faà de Bruno's valuable *Théorie des formes binaires*, Turin, 1876, at the foot of page 150 occurs the following passage: "Cela suppose essentiellement que les équations de condition *soient toutes indépendantes entr'elles, ce qui n'est pas toujours le cas*, ainsi qu'il résulte des recherches du Professor Gordan sur les nombres des covariants des formes quintique et sextique."

The reader is cautioned against supposing that the consequence alleged above does

result from Gordan's researches, which are indubitably correct. This supposed consequence must have arisen from a misapprehension, on the part of M. de Bruno, of the nature of Professor Cayley's rectification of the error of reasoning contained in his second memoir on Quantics, which had led to results discordant with Gordan's. Thus error breeds error, unless and until the pernicious brood is stamped out for good and all under the iron heel of rigid demonstration. In the early part of this year Mr. Halsted, a fellow of John's Hopkins University, called my attention to this passage in M. de Bruno's book; and all I could say in reply was that 'the extrinsic evidence in support of the independence of the equations which had been impugned rendered it in my mind as certain as any fact in nature could be, but that to reduce it to an exact demonstration transcended, I thought, the powers of the human understanding.'"

In 1883 Sylvester was made Savilian professor of geometry at Oxford, the first Cambridge man so honored since the appointment of Wallis in 1649.

To greet the new environment, he created a new subject for his researches—Reciprocants, which has inspired, among others, J. Hammond, of Oxford; McMahon, of Woolwich; A. R. Forsyth, of Cambridge; Leudesdorf, Elliott and Halphen.

Sylvester never solved exercise problems such as are proposed in the *Educational Times*, though he made them all his life long down to his latest years. For example, *unsolved* problems by him will be found even in Vol. LXII. and Vol. LXIII. of the *Educational Times* reprints (1895). If at the time of meeting his own problem he met also a neat solution he would communicate them together, but he never solved any. In the meagre notices that have been given of Sylvester the strangest errors abound. Thus C. S. Pierce, in the *Post*, March 16th, speaks of his accepting, 'with much diffidence,' a word whose meaning he never knew; and gives 1862 as the date of his retirement from Woolwich, which is eight years wrong, as this forced retirement was July 31, 1870, after his 55th birthday. Cajori, in his inadequate account (History of Mathematics, p. 326), puts the studying of law before the professorship at University College and the professorship at the University of Virginia, both of which it followed. Effect must follow cause. And strange, that of the few things he ascribes to Sylvester, he should have hit upon something not his, "the discovery of the partial differential equations satisfied by the invariants and covariants of binary quantics." But Sylvester has explicitly said in Section VI. of his 'Calculus of Forms:' "I alluded to the partial differential equations by which every invariant may be defined. M. Aronhold, as I collect from private information, was the first to think of the application of this method to the subject; but it was Mr. Cayley who communicated to me the equations which define the invariants of functions of two variables."

Surely he needs nothing but his very own, this marvellous man who gave so lavishly to every one devoted to mathematics, or, indeed, to the highest advance of human thought in any form.

George Bruce Halsted.
University of Texas.

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*THE GREAT FAULT AND ACCOMPANYING SANDSTONE DIKES OF UTE PASS, COLORADO.**

Three year years ago Whitman Cross first directed the attention of geologists to the fact that dike-like masses of sandstone occur in the granite of the Pike's Peak massif, forming a belt about one mile wide extending north-northwest from the vicinity of Green Mountain Falls, in Ute Pass,

*Abstract of a paper read before the Boston Society of Na al History, January 20, 1897.

along the southwest side of the narrow Manitou Park, basin of sedimentary rocks (Silurian and Carboniferous). Among the more important characteristics of the dikes noted by Cross are the following: 1. The dikes have a general trend parallel to the belt in which they occur; are approximately vertical and often appear as a complex of nearly parallel fissures with many branches and connecting arms; and vary in width from mere films to two or three hundred yards, the largest being a mile or more in length, and forming rugged ridges with narrow crests which contrast markedly with the gentle sloping hills of granite about them. In short, "In all formal relationships to the enclosing rocks these bodies are as typical dikes as any of igneous origin." 2. The rock of the dikes is a fine and even-grained aggregate of sand grains varying in degree of induration from a normal sandstone to a dense hard quartzite, but throughout of a remarkably massive and uniform character.

During the past summer of 1896 I was able to devote several weeks to the investigation of the sandstone dikes and the great displacement to which I have found them to be genetically related. To the dikes described by Cross I gave only sufficient attention to become familiar with their characteristics, and then endeavored to trace the series southeastward through Ute Pass to Manitou and beyond.

The sedimentary formations of the Manitou area embrace, from below upward, as described by Hayden, Cross and others: 1. A basal sandstone which is usually 40 to 50 feet thick, white or gray for the lower 10 to 15 feet and dull red or brown above, only rarely of arkose character, but frequently more or less glauconitic. 2. This sandstone, which may be referred provisionally to the Potsdam, becomes calcareous upward, passing into red, cherty limestones, and these into a massive gray limestone having a thickness of several hundred feet. The limestones are throughout more or less magnesian and contain recognizable traces of a Lower Silurian (Ordovician) fauna. 3. This great Manitou limestone series is overlain without apparent unconformity by the Fountain (Carboniferous) beds 1,000 to possibly 1,500 feet in thickness—a remarkable complex of red and white arkose sandstone, grits and conglomerates. 4. The red sandstone series (Triassic), a thousand feet or more in thickness. 5. The white, variegated and gypsiferous Jurassic strata. 6. The Cretaceous series, beginning with the massive and conspicuous Dakota sandstone.

Each of these formations is cut off on the south by the great fault which skirts the northeastern base of the Pike's Peak massif. This profound displacement, which must be regarded as a dominant factor in the geological structure of the region, and to which we undoubtedly owe, in the main, the Manitou embayment of sedimentary rocks and the exceptional elevation of the Pike's Peak massif as compared with the Front Range to the north of Ute Pass, gained early recognition and is clearly indicated on Hayden's maps of the Manitou area. It is altogether probable that the fault by which Cross has bounded the Manitou Park sediments (Potsdam, Manitou limestone, and Fountain series) on the southwest is a direct continuation of that which, cutting across the strike of the beds, is so much more conspicious in the Manitou area. This great displacement, which divides very obliquely the entire Front Range and the beds lying upon either flank of the range and sloping away from its crest, may therefore be appropriately designated the Ute fault. Erosion has cut deeply enough over the top of the arch to remove the sedimentary rocks from the down-throw as well as the up-throw side of the fault. The Ute fault cuts every formation of the region from the fundamental

granite and the Potsdam to the Laramie, and in its maximum throw must exceed the aggregate thickness of the Paleozoic and Mesozoic terranes; and its completion, at least, must date from relatively late geological times.

I have succeeded in tracing the sandstone dikes from the vicinity of the Iron Spring, in Manitou, northwest along the great fault two miles, or a little farther than the sedimentary rocks extend, and southeastward from Manitou, along the base of the mountains, and closely following the Ute fault, to Cheyenne Cañon and beyond, a distance of six miles. The dikes of this series vary in width up to 500 or 600 feet. A large dike usually follows the main line of displacement, separating the sedimentary rocks and granite, with one to several other dikes closely parallel with it in the granite. Almost without exception the dikes exhibit a strong southwesterly hade, making angles of 5 to 75 degrees with the vertical, and slickensided shear planes at corresponding angles are very common. Although the rock is prevailingly a fine and even-grained gray and reddish-brown sandstone, identical with that described by Cross, much of it is decidedly coarser, and at several points it is distinctly conglomeratic. In several dikes, also, the sandstone is more or less distinctly stratified.

Mr. Cross has briefly discussed the origin of the sandstone dikes, without arriving at a definite conclusion. He recognizes that these sandstone dikes are radically distinct in character and origin from those described by Diller in California, and asserts that the known facts do not indicate the source of the sand; that the facts do show that the fissures of this dike complex were filled by fine quicksand injected from a source containing a large amount of homogeneous material; that such a system of fissures, large and small, with their many intersections, could not remain open to be filled by any slow process; that the uniformity and purity of the material filling fissures varying from mere films on cleavage planes of orthoclase grains in the granite to dikes several hundred yards in width could not have resulted from infiltration; and, finally, that none of the sedimentary formations of the region can be regarded as probable sources of the material.

My study enables me to accept all of these generalizations, except the last one. The most important of the facts which the true theory of the dikes must explain are: first, their very evident close relationship to an important zone of displacement; second, the homogeneity of the materials and the general absence of stratification in the dikes; third, the great maximum and average widths of the dikes.

The relations of the dikes to the great Ute fault are indisputable. Not only is the fault at most points closely accompanied by one or more dikes; but nowhere have I been able to find any trace of the dikes more than a few hundred feet (500 to 1,000 feet) distant from the principle line of displacement. That these fissures, unlike the relatively narrow ones described by Diller in California, have not been filled from below becomes perfectly obvious when we reflect that the inclosing rock formation is a deep-seated plutonic. The homogeneity and purity of the sandstone, and especially the absence of feldspathic or argillaceous material, make it impossible to regard the dike rock as a fault breccia or as due in any way to the comminution of the wall rock. Ruling out this theory and infiltration, we are forced to the conclusion that the fissures have been filled from above. But of this theory two principal forms naturally suggest themselves. First, the fissures antedate the deposition of the sand, existing as cracks in the sea-botton which were filled by the slow process of sedimenta-

tion. Second, the cracks post-date the deposition of the sand, but antedate its lithification to form a firm sandstone and the unconsolidated sand subsided and flowed down into and filled the fissures.

By this process of elimination we are forced to the consideration of the view that the fissures were formed after the granite had been covered by the sedimentary deposits and before their complete consolidation, the unconsolidated portions naturally contributing to the filling of the fissures and the formation of the dikes. There are two questions especially which the acceptance of this explanation would require to be answered in the affirmative. First, are there, among the sediments of the Manitou and Manitou Park basins, any that, aside from structural features like stratification, which would, of course, be obliterated during the filling of the fissures, present a reasonably close agreement in character (composition and texture) with the sandstone of the dikes? Second, may we reasonably assume that these sediments were, in part at least, unconsolidated or imperfectly consolidated at the time when the fissures were formed? The only sandstone formations that need be considered in this connection are the Potsdam, Carboniferous, Triassic and Dakota. Of these four sandstone horizons the last three bear no special resemblance to the material of the sandstone dikes. On the other hand, I became convinced before the field work was finished that the Potsdam beds and the dikes are lithologically identical. The dike rock is absolutely indifferent to the changes in the character of the neighboring formations, showing no appreciable variation, as in succession, from Manitou southeast to Cheyenne Cañon, the Potsdam, Silurian, Carboniferous, Triassic and Dakota beds abut against or border the great fault.

The close association of the dikes, throughout the entire belt, with the great displacement, and their unvarying lithological similarity to the Potsdam sandstone, have suggested to me that the dikes probably date from the formation of the Ute fault; that the fault probably dates from the time when the Potsdam beds, which are still, at the base, in part of a more or less friable character, were imperfectly consolidated and covered the entire region; that the fault, as is likely to be the case with a great displacement, was not simple, but that a moderate breadth of the granite and overlying formations was traversed by a series of parallel fissures; and that the dikes resulted from the sinking of the Potsdam sandstone and sand into the fault fissures. Such local subsidences of the friable sandstone would naturally be attended by a more or less complete obliteration of the bedding.

No single feature of the dikes is more significant than the great breadth of individual examples. Although presenting, apparently, an insuperable obstacle to all the other suggested explanations of the sandstone dikes, it offers no difficulty whatever to the theory proposed here, for we have only to make the extremely probable supposition that sheets of granite of varying width and bordered by complementary faults have settled down relatively to the bordering masses, bearing with them their loads of Potsdam sediment.

W. O. CROSBY.

EXHIBITION IN SCIENCE BY THE NEW YORK ACADEMY OF SCIENCES.

THE Fourth Annual Exhibition of Recent Progress in Science, given by the New York Academy of Sciences, was held at the American Museum of Natural History on April 5th and 6th, and was in every way the most successful in the history of the Society. The exhibit occupied the floor space of the main hall and bird gallery, and was attended by an estimated number of more

than three thousand people. The first evening was devoted to a reception to the members of the Academy and a few invited guests, and was more or less social in its nature. On the afternoon of the second day the visitors included many from the public and private schools of city who were especially invited. On the second evening the reception was to members of the Scientific Alliance and other friends, and the occasion was more informal and public than on the previous evening.

Besides the Exhibition, the committee had planned a program of considerable interest, for the second evening, including a short informal talk by Dr. Nicola Tesla on 'The Streams of Lenard and Röntgen.' Dr. Tesla gave a short synopsis of some of his more recent discoveries and exhibited several pieces of apparatus for producing high power, electrical currents with simple machines. This talk was preceded by a short review of the scientific results of the year by Professor J. J. Stevenson, President of the Academy, and an address of welcome by Mr. Morris K. Jesup, President of the Museum, to whose courtesy and hospitality much of the success of the occasion was due.

In every way the success of the Exhibition was very great and very encouraging to workers in science, for the manifest interest of the large numbers of people attending was a striking sign of the times. Interest, and not popular curiosity, attracted the greater number of visitors. The attention that the Exhibition was given both by people of New York and the newspapers showed that this annual feature of the Academy is fast becoming one of the occasions of the year to which many people look forward with very great anticipation.

The reception was in charge of a committee of Professor Henry F. Osborn, Mr. Charles F. Cox and Professor Richard E. Dodge. They were assisted in the planning of the details and in the execution thereof by a committee of one from each department represented, of which a list follows: Anatomy, Professor George S. Huntington; Astronomy, Professor J. K. Rees; Botany, Professor L. M. Underwood; Chemistry, Professor Chas. A. Doremus; Electricity, Mr. George F. Sever; Ethnology and Archæology, Mr. Franz Boas and Mr. M. H. Saville; Experimental Psychology, Professor J. McK. Cattell; Geology, Professor J. F. Kemp; Mineralogy, Mr. George F. Kunz; Paleontology, Mr. Gilbert van Ingen; Photography, Professor William Stratford; Physics, Professor William Hallock and Professor J. F. Woodhull; Physiography, Professor R. E. Dodge; Zoölogy, Professor C. L. Bristol and Mr. Bashford Dean.

The exhibits that received the most attention were naturally those concerning which there has been the most said publicly within the last year. The electric furnaces, including the one used by Dr. Henri Moissan in his lectures before the Academy; the outfits for illustrating the uses and effects of the Röntgen rays, and the instruments of fatigue in experimental psychology were continually surrounded by a large number of interested listeners and spectators.

Inasmuch as the Exhibition was arranged to show progress during the last year only, there were few duplications of former exhibits in any department. Everything shown was in a way new and received attention in proportion to its importance. The chairmen of the departments were in attendance during most of the time and gladly answered questions and explained particular points of interest. In this way the visitors felt that they were guests rather than sightseers. Nothing of an advertising character was allowed, and hence the air of the whole Exhibition was serious and truly scientific.

Besides the exhibits that were mentioned

above as being the most attentively studied, there were many other exhibits worthy of mention, of which only a few can be spoken of here. In chemistry, besides the exhibits noted, the most interesting materials were the artistic glasses exhibited by the Tiffany Decorative Company, and several striking pieces of apparatus exhibited by the chairman.

In electricity the enclosed arc lamps, the Crookes tubes and fluoroscopes received a great deal of attention. In ethnology and archæology the busts of the Kwakiutl Indians and the paintings, diagrams and specimens illustrating the culture of the primitive American races were the more notable exhibits.

In geology the exhibit of clays from various parts of America and the products made therefrom won a great deal of well deserved attention. The photographs from the Cornell Greenland expedition illustrating some of the conclusions of Professor Tarr regarding the effects of glaciers in Greenland were of interest both to the unscientific and the scientific. The associated subject mineralogy had on exhibition a large series of new and valuable specimens which cannot be noted here in detail. In paleontology was one of the largest exhibits that took the greatest amount of labor in arranging. The exhibit included fossils from some of the more important localities illustrating the work accomplished by leading paleontologists of the East. Besides the stratigraphic collections exhibited, there was a large series of fossil insects from Florissant, Colorado, including some very handsome butterflies exhibited by Mr. S. H. Scudder. The preparations of Beecher, of Yale University, illustrating the structures of Trilobites, were much studied, representing, as they do, the best knowledge of what has been until recently but little known. The fossil gums including insects of all kinds also deserve a note. In vertebrate paleontology there was a large collection of fossils from the American Museum, and some striking water colors of the reproductions of extinct mammalia.

The exhibit in photography included some very beautiful prints and some of the more recent apparatus, and received much attention. It was, however, disappointing to those in charge because so many exhibitors failed to send promised materials, some of which were of especial interest and value.

In physiography the exhibit included several large models of New England and New York, representing the newest and best work of Mr. Howell, of Washington. A series of teaching models from Professor W. M. Davis, which have just been cast, also were exhibited uncolored. These models represent the best work of the year outside of the numerous publications.

In zoology the most important exhibition was the collection of animals from the Puget Sound region, exhibited by Columbia University. Many of the forms represented were shown in all stages from embryonic to adult and are very valuable additions to our knowledge of the lower animals. The plans and models of the new Zoological Park of New York City also were shown in some detail and naturally received very much attention.

The Exhibition represents a large investment of time and labor on the part of the few in charge, and should bring very valuable results to the Academy in many ways. It has aroused considerable interest in many places at a distance from the city, and it is hoped that the plan of having such exhibitions may be followed by other scientific societies in the country. If scientists would have the support of the public they must show their work. There is no better way to show work than by a scientific exhibition in which the popular and wonderful are exhibited together with the more valuable and enduring. The committee in

charge feel that the investment of time, money and labor has paid for itself, for the interest we have aroused has been an inspiration to all of us and, we think, to many others. It has shown that science has a very strong hold upon the public and that the public appreciate the work of abstruse science, whether or not it shows immediate results from an economic standpoint.

RICHARD E. DODGE.

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*THE MISSOURI BOTANICAL GARDEN.**

DURING the year 1896 the ornamental features of the Garden were of the same general character as heretofore, and about the same number of species and nearly the same of individuals were cultivated for this purpose, in the open air, as in 1895. The house collections, on the other hand, especially that of orchids, have been considerably increased, both in size and variety. A conservative estimate by the Head Gardener shows that at present about two and one-half times as many species and named varieties of plants are cultivated as in 1889. At the end of 1895 an inventory of the plants in cultivation at the Garden showed that 3921 species and varieties other than annuals were cultivated at that time. During the past year, while considerable additions have been made, it is probable that certain species have dropped out of cultivation, so that in the absence of a special inventory it is possible to state merely that the number now in cultivation is unquestionably somewhat greater than that in 1895.

It is estimated that, for various temporary reasons, the number of visitors to the Garden during 1896 was scarcely as large as in the preceding year. On the open Sunday afternoon in June 10,598 persons passed the gate, and on the corresponding Sunday afternoon in September 13,589 visitors were counted. So far as estimates can be made from the data at hand, the number of visitors to the Garden is now about one-half greater than in 1889, though, as no automatic register of visitors is kept at the gate, the estimates are not accurate.

As a result of the most destructive hail-storm that has ever been experienced at the Garden, some 6,000 lights of glass were broken on tne 21st of May last, the falling glass doing incalculable damage to many of the plants, which were further exposed to the weather for a considerable time. Cacti and other plants which are sheltered under glass during the winter, but which had been placed in the rockeries and elsewhere before the storm, were either destroyed or so badly bruised that it is impossible even yet to count the final loss. Some idea of the force of the falling hail may be obtained from the statement that the ribbed glass on the roof of the Linnæan house, nearly a quarter of an inch thick, was in considerable part broken.

Closely following this storm, the tornado of May 27th, which caused great loss of life and property in and about St. Louis, devastated a considerable portion of the Garden. While the grounds, fortunately, were not actually traversed by the cyclonic funnel, but were exposed only to the strong northwest gale which accompanied it, the violence of the wind was such that a number of the structures on the grounds were either unroofed or totally wrecked, while some 450 trees, many of them of large size, were totally or practically destroyed, and a large percentage of those left standing were seriously broken. A more graphic view of the destruction of trees may be obtained from the statement that 186 cords of firewood have been prepared from the more workable trunks and larger branches of the trees removed. Aside from the direct injury, it is probable that no small number of those left have suffered from unwonted ex-

*From advance sheets of the eighth annual report of the Director, Professor Wm. Trelease.

posure to the strong sunlight of last summer and the winds of the present winter, so that many more are almost certain to require removal during the next year or two.

During the period of time covered by this, report the herbarium has increased from 159,046 unmounted specimens, constituting the Engelmann and Bernhardi herbaria, to 258,629 mounted specimens, protected by impregnation with corrosive sublimate. The library, which at first contained considerably less than 5,000 volumes and pamphlets, has increased to 23,257, valued at nearly $40,000.

Notwithstanding the provision of safe and, for the time being, ample quarters for the library and herbarium in the reconstructed city residence, it has not yet been found practicable to remove the numerous wood specimens, and other unattractive but necessary and valuable material, from the old museum building, so as to free the latter for other uses; nor has it proved possible to spare funds for the purchase of material and the salary of an assistant who should be charged with the installation and maintenance of a museum illustrating some branch of pure or applied botany, such as might be accommodated in this small building were it empty.

Aside from an increase in the plant-houses, and the accumulation of books, living and preserved specimens of plants and their parts, and a small collection of insects, no considerable facilities for research have been acquired at the Garden thus far, the instrumental equipment of the School of Botany being found available for all necessary use by the few Garden employees and pupils, and, as yet, no properly equipped permanent laboratory rooms have been provided, adequate temporary provision being made in the herbarium building and the plant-houses for such work as has been undertaken. While in some respects much remains to be done, such facilities as have been secured thus far have been placed at the disposal of investigators, of whom one or more have occupied tables at the Garden for a period of from one month to a year, each season for several years past, three such investigators having been accommodated at the Garden during the current autumn and winter. By direction of the Board, a general announcement is made, by a widely distributed circular, in the early part of each year, that such facilities as the Garden possesses, or can readily acquire for any worthy piece of investigation, are freely placed at the disposal of competent investigators.

THE GANODONTA OR PRIMITIVE EDENTATES WITH ENAMELLED TEETH.

THE discovery of the forefoot of *Psittacotherium* in the upper division of the Puerco beds (New Mexico) is one of the most fortunate accidents in the recent history of paleontology, because of its remarkable likeness to the foot of the sloth. This likeness at once suggested to Dr. J. L. Wortman the relationship of *Psittacotherium* to the Gravigrada, or great Ground Sloths. Upon his return to the American museum from the field the entire collection was placed in his hands, and it soon appeared that a series of animals which had been referred to the Creodonta, to the Tillodontia and to other orders formed in reality a part of a genetic series pointing conclusively toward the modern sloths, especially towards *Megalonyx*. The evidence is summed up in Dr. Wortman's recent paper, as follows:

*(1) In the skull there is great similarity in form; the muzzle is short, the sagittal crest is low, and the occipital plane slopes forwards as in Mylodon, Megatherium and Megalonyx. (2) The lower jaw is short, deep and robust, with a greatly enlarged coronoid, a prominent angle, and a

*'The Ganodonta, and their relationship to the Edentata.' Bull. Am. Mus. Nat. Hist., March 22, 1897.

position of the condyle high above the tooth line. (3) The incisors are reduced to a single pair in the lower jaw of *Calamodon*, and are probably completely absent in *Stylinodon*. (4) The posterior portion of the tooth line below passes well behind the anterior border of the coronoid. (5) The canines in all are enlarged, and in *Calamodon* and *Stylinodon* grew from persistent pulps, as in Megalonyx. (6) All the molars and premolars in *Stylinodon* are greatly elongated, of persistent growth, and the enamel is confined to narrow vertical bands. (7) There is a thick deposit of cementum on the dentine in those situations in which the enamel disappears. (8) The cervical vertebræ strongly resemble those of the Gravigrada. (9) There were well developed clavicles present. (10) The humerus bears a striking resemblance in all of its essential features to those of *Mylodon*, *Megalonyx* and *Megatherium*. (11) The ulna and radius are also similar. (12) The manus is almost identical with that of the ground sloths. (13) The humerus and ulna and radius have no medullary cavities; and (14) the femur has all the characteristic features of the Gravigrada. (15) The lumbar vertebral formula was the same as in the Edentata. (16) The pelvis is decidedly Edentate and (17) the caudals bear a striking resemblance to those of the Ground Sloths."

It follows, or at least is extremely probable, that not only the Gravigrada, but all the South American Edentates had their origin in North America. Thus a group which has been traditionally assigned to South America now appears to have taken its origin in the north, for the sloths first appear in the Santa Cruz beds of Patagonia, which are not older than the North American White River beds or Oligocene, whereas in North America they are found immediately over the Cretaceous. The importance of this discovery can hardly be exaggerated, both because of its bearing upon phylogeny, and upon geographical distribution. It appears certain that there was an early land connection between North and South America, and it is in the highest degree improbable that the sloths found their way to South America by way of Asia and Antarctica, as Lydekker has suggested. This early land connection enables us to connect the South American Ungulates, especially the Litopterna, with the American Condylarthra, as Cope and others have suggested, so that it will throw renewed life into the study of the genetic relations of these northern and southern faunas. Another important result is, that the Edentates are proved to be of tritubercular origin, thus reinforcing the evidence of a trituberculate stem form of all the mammalia.

H. F. O.

CURRENT NOTES ON METEOROLOGY.

THE EXPLORATION OF THE AIR.

In *Appalachia*, Vol. VIII., No. 1, pp. 179–189, Mr. A. L. Rotch has a paper on 'The Exploration of the Free Air,' in which he gives a general outline of the way in which this work is being done, by means of mountain stations, balloons, cloud measurements and kites. The following facts are of general interest: The first summit station in the world was established on Mt. Washington, N. H. (6,280 ft.), in 1870. The Pikes Peak station (14,134 ft.), now closed, was for many years the highest in the world, but at present the highest station is that of the Harvard College Observatory on the summit of the volcano El Misti, in Peru (19,200 ft.). On Mont Blanc there is a station at the Rochers des Bosses (14,320 ft.), operated during the summer, and on the summit (15,780 ft.), the latter still being idle. The Sonnblick (10,170 ft) in the Austrian Alps; the Saentis (8,200 ft) in Switzerland; Monte Cimone (7,100 ft.) in the Apennines, near Lucca, and Ben Nevis (4,400 ft.) in Scot-

land, are the other well-known high altitude stations. Epoch-making balloon ascents were those of Dr. John Jeffries, of Boston, who made the first scientific balloon voyage from London in 1784; Gay Lussac in 1804 (23,000 ft.); Coxwell and Glaisher in 1862 (29,000 ft.), and Crocé-Spinelli, Sivel and Tissandier, in 1875, in which the two former were asphyxiated. In 1894 Berson ascended alone to an altitude of about 30,000 ft., his barometer reading 9.1 inches, and the minimum temperature being –54° Fahr. Pilot balloons, without aëronauts, have ascended over 10 miles on two occasions, the 'Cirrus' in July, 1894, bringing down a barograph reading of 3.3 inches, and a thermograph reading of –64° Fahr.

VISIBILITY OF MOUNTAINS AND ATMOSPHERIC DUST.

A PAPER by Schultheiss, in the *Meteorologische Zeitschrift* for December, discusses a matter of some interest that has not yet been much considered. It concerns the effect of the dust in the atmosphere in relation to the greater or less visibility of distant mountains. Observations on the visibility of the Alps have been made for 20 years past at Höchenschwand, a station in the southern Black Forest, at an altitude of 1,000 meters and commanding, under favorable conditions, an extended view of the Alps as far as Mont Blanc. Three degrees of visibility are noted, designated respectively as 0, 1 and 2, the latter figure denoting the greatest clearness of view. A careful study of the records and of the weather conditions prevailing at the times of observation reveals the fact that the visibility is best under anticyclonic conditions or during the prevalence of a foehn wind. In both cases there is a descending movement of the atmosphere, and as the upper strata are cleaner and purer than the lower this process results in causing greater clearness of the air and hence a higher degree of visibility. Ninety per cent. of all the cases in which the view of the distant Alps was clear are found to be associated with such anticyclonic or foehn conditions. Cleaning the air by means of rain seems to be the controlling factor in the majority of the other 10 per cent. of cases. Naturally, as anticyclones are more frequent and longer-lived over central Europe in winter, the visibility is greater in winter and less in summer. There is a common belief, here as well as in Europe, that very clear days, which give very good views of distant mountains, are most likely to be followed by rain. Schultheiss has investigated this question in the case of the Alps as seen from Höchenschwand, and finds that an especially clear view is seldom closely followed by rain. He also finds that the dust in the atmosphere at 1,000 meters is very fine and does not include large quantities of coarser smoke particles as it does at lower levels.

THE BLUE HILL METEOROLOGICAL OBSERVATORY.

IT is a very great satisfaction to learn from the volume of Blue Hill Observations for 1895 (Annals Harv. Coll. Obs'y, Vol. XL., Pt. V.) that the President and Fellows of Harvard College have secured from the Metropolitan Park Commissioners of Boston a lease of about one and a quarter acres of land on the summit of the Hill. This lease is for ninety-nine years, and will enable the work of the Observatory to be continued without any change in the present conditions of exposure of the instruments. There was some fear, when, a few years ago, the Metropolitan Park Commission added the Blue Hills to the Boston Park system, that the future usefulness of the Observatory might be seriously interfered with by the possible erection of buildings in its vicinity. It would have been a very serious loss to science, not only in this country but in the

world, had anything happened to interfere in any way with the work that the Blue Hill Observatory has been doing so admirably since its foundation. The present volume of observations contains the usual data for the year and, in addition, summaries for the lustrum and decade, with a discussion of the annual and diurnal periods, by Clayton. A number of interesting points are brought out, among them the grouping of thunderstorms around certain dates; the occurrence of maxima in the frequency and amount of snowfall at intervals of twenty or thirty days; of the greatest snowfall in February, and of a minimum of rainfall in June, with a maximum in October.

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CURRENT NOTES ON ANTHROPOLOGY.

THE SO-CALLED 'BOW-PULLERS' OF ANTIQUITY.

This is the title of a carefully prepared essay by Professor Edward S. Morse, in the *Essex Institute Bulletin*, Vol. XXVI., the essential facts of which have been copied in *Globus*, Bd. LXXI., No. 10, and other foreign journals. The subject discussed is the purpose of certain objects of bronze or iron found in Greek, Roman and Etruscan tombs. These objects are two connected rings of the metal about seven centimeters in full length, the space between them being about two centimeters, from which space three or four knobs, projections or spines, of irregular height, arise.

Professor Morse proves that these objects can be neither bow-pullers, spear throwers, curbs, bits, caltrops, nor anything else which has been proposed by classical archæologists; but what they are, he says, after seven years' study, he cannot suggest, nor do the European editors who have republished his article offer an explanation.

I take, therefore, some special pleasure in solving this enigma, and in identifying this curious and puzzling object. It is without doubt the Greek *myrmex* (μύρμηξ) which, in pugilistic encounters, was strapped or chained on the hand over the leathern cestus. This identification answers every condition of form, material, decoration and use mentioned by Professor Morse. I shall shortly publish an article giving the Greek and Latin authorities at length, confirming this opinion.

FAIRYLAND.

In his presidential address, published in *Folk-lore* for March, Mr. Alfred Nutt discusses the origin of the fairy-lore which has been such a prominent feature in English literature and rustic narrative. He brings together many reasons for attributing it to a Celtic source. It is, in fact, a survival of the belief in the pre-Christian, pagan gods of the Celtic tribes. These have been best remembered in Ireland, where they are still spoken of as the *tuatha de Danann*—the folk of the goddess Danu; and they are to this day considered the occupants of the fairy hillocks.

Mr. Nutt does not explain why the fairies were considered very little beings, as this is not mentioned in the earliest Irish myths. I may suggest that there are reasons for believing that the goddess Danu was the moon (from the O. I. verb, *daon*, to arise, to ascend; and compare Harley, *Moon-lore*, p. 121), and her followers, or folk, the little twinkling stars; whence by an easy step of personification they were transformed into the tiny fairy folk.

RECENT ETRUSCOLOGY.

The 'Etruscan problem' is one of perennial interest, and now that the Metropolitan Museum of New York and that of the University of Pennsylvania have acquired large and valuable collections from ancient Etruria, the affinities of its mysterious in-

habitants have an increased attraction for American students.

In the February number of the *Journal of the Anthropological Institute* the eminent antiquary, Dr. Oscar Montelius, offers some new views on the subject. He identifies the Etruscans of Italy with the Tyrrhenians and the Pelasgians, and the earliest Etruscan culture with the Mycenean. Both, he believes, emerged from Asia Minor, the Etruscans reaching Italy by sea about 1050 B. C., bringing with them their peculiar alphabet. The 'Tursha' of the Egyptian inscriptions of the 13th century B. C., he argues, were the Tyrrhenians.

In the discussion which followed, some of these views were opposed by Mr. Arthur Evans and Mr. J. L. Myres, the former maintaining that the 'root elements' of the Mycenean civilization were European and not Asiatic; and the latter referring with approval to the theory that the Etruscans belonged to the Hamitic stock of North Africa, advanced on linguistic grounds by myself.

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NOTES ON INORGANIC CHEMISTRY.

A RECENT number of *Nature* (March 11th) contains an interesting review, by T. K. Rose, of the extraction of gold by chemical methods; much of the gold in ores is in a state of very fine division, the particles being often less than one thousandth of an inch in diameter, and sometimes less than one twelve thousandth. Such particles are much more readily dissolved by chemical means than by mercury. In sulfid ores, too, mercury is an unsatisfactory solvent. Such ores have until lately been worked by the chlorination process, which is now nearly fifty years old. The sulfids must, however, be very completely roasted, as the chlorin has a greater preference for sulfids than for the gold. When alkaline earths are present, salt must be added in the roasting. This however occasions, save in the improved furnaces, a loss of chlorid of gold by volatilization. The ore is generally treated with chlorin water in large vats or in revolving barrels under pressure. The plant at Mount Morgan, Queensland, is the largest in the world, 1500 tons of ore being treated at a cost of $4.50 per ton, about $25 in gold being recovered for each ton. The gold is best precipitated from the chlorin solution by hydrogen sulfid, though iron sulfate or charcoal in boiling solution may be used. On account of the expense of roasting and the non-recovery of any silver in the ore, the chlorination process is being gradually superseded by the cyanid process, which, while hardly recovering the gold as completely as the former, can be used with sulfid ores directly, and which recovers also any silver present. It has been long known that potassium cyanid in dilute solution dissolves gold, especially in the presence of air, with the formation of potassium aurocyanid, $K\,Au\,(CN)_2$, and this reaction is used practically in the process introduced by MacArthur and the Forrests. The action of the cyanid is most rapid in one-fourth per cent. solution, but at the best it is slow, and Sulman and Teed propose to hasten it by the addition of cyanogen bromid. The gold is precipitated either by zinc shavings, or, less commonly, by electro-deposition with iron cathodes and anodes of lead foil. The use of zinc is cheaper, but $1\frac{1}{2}$ to 2 dwts. of gold per ton of liquid remain unprecipitated, and the gold obtained is only about 700 fine. The electrolytic process is more complete and the bullion produced is very fine. At the Worcester mine, in the Transvaal, seventy tons of liquid are treated a day at an expenditure of five horse power, and 12,000 square feet of surface of lead are exposed.

The cyanid process enables low-grade

ores to be worked successfully, and it may be expected that these ores, such as those of the Rand, will be the most important source of gold in the future.

J. L. H.

SCIENTIFIC NOTES AND NEWS.

We record with deep regret the death of Professor Edward D. Cope, professor in the University of Pennsylvania, editor of the *American Naturalist*, President of the American Association for the Advancement of Science, and eminent for contributions to paleontology, zoology and a wide range of natural science. Professor Cope became seriously ill on Tuesday of last week and died on Monday from uræmic poisoning. In his death science has suffered an irreparable loss, and for many the personal loss is equally severe.

The German Zoological Society proposes to hold its seventh annual meeting at Kiel on June 9th–11th, under the presidency of Professor O. Bütschli, of Heidelberg. Reports are expected from Professor Brandt on the fauna of the Baltic Sea, and by Professor Chun on the *Siphonophora*. The report of the editors of *Das Tierreich*, which is published under the auspices of the Society, will also be presented. Lectures and demonstrations are announced by Professor B. Henson on the North Sea Expedition of 1895, by Dr. Apstein on the Methods and Apparatus of Modern Marine Biological Investigations, and by Dr. Vanhöffen on the Marine Fauna of Greenland.

Mr. C. H. Townsend has been appointed Chief of the Division of Fisheries, U. S. Fish Commission, while Dr. H. M. Smith is assigned to the Division of Scientific Inquiry. Mr. Townsend has been connected with the U. S. Fish Commission for fourteen years and has for a long time held the position of Naturalist on the Albatross which he now relinquishes. He is especially familiar with the fisheries of the Pacific Coast, including the many problems connected with the salmon canning industry, which is prosecuted under such varying conditions in the United States and Alaska that no one law can be made applicable to all localities. Mr. Townsend also has a long acquaintance with the fur seal question, and it is to his investigations that we owe most of our knowledge concerning the food, breeding habits and migrations of this animal.

A second circular of the Committee of Arrangements for the International Geological Congress has been issued and the Committee announces a most attractive program. As we have already stated, three excursions are arranged before the Congress: to the Ural region, to Esthonia and to Finland. After the Congress the chief excursion is to the Caucasus, leaving St. Petersburg on the 24th of August in three groups, each under special directors. All the details have been worked out with the greatest care, and expenses are reduced to a very low figure by practically free transportation and by hospitality offered by many of the large cities. The Finland excursion, for example, is estimated at only fifty francs, while the very extensive excursion to the Caucasus is estimated at six hundred and sixty-five francs. The sessions of the Congress take place at St. Petersburg between the 17th and 23d of August, in the rooms of the Imperial Academy of Sciences.

At a meeting in the rooms of the Royal Society in 1893, the Prince of Wales in the chair, it was unanimously resolved "that the eminent services of the late Sir Richard Owen in the advancement of the knowledge of the sciences of anatomy, zoology and paleontology should be commemorated by some suitable memorial." A fund was collected for a bronze statue, which has been executed by Mr. Thomas Brock. This statue has just been placed in the Central Hall of the Natural History Museum, where it stands facing Boehm's statue of Darwin.

The annual meeting of the American Institute of Electrical Engineers will be held in New York on May 18th. The Council have nominated Professor Francis B. Crocker, of Columbia University, for President. The Institute will hold a general meeting at Greenacre, Maine, beginning on July 26th.

The Women's National Science Club met in the lecture room of the National Museum, Washington, on April 7th, 8th and 9th. Many

papers were presented covering a wide range of scientific subjects.

WE regret to record the death of Dr. Edson S. Bastin, professor of materia medica and botany at the Philadelphia College of Pharmacy, from cerebral hemorrhage, at the age of fifty-four years. Professsr Bastin's text-books, 'Elements of Botany' and 'College Botany,' are extensively used, and he was the author of numerous researches in pharmaceutical botany.

THE biological laboratory of Cold Spring Harbor, L. I., conducted under the auspices of the Brooklyn Academy of Arts and Sciences, will again this year be under the direction of Professor H. W. Conn, of Wesleyan University. The laboratory will be open for research work after the middle of June, and the regular courses will begin on July 7th and continue for six weeks.

PROFESSOR JOHN M. MACFARLAND, of the University of Pennsylvania, has arranged an Easter botanical excursion for his students, who will camp in the neighborhood of Savannah, Ga.

MR. E. P. SHELDON, lately instructor in botany at the University of Minnesota, has accepted a commission from the National Herbarium to organize a field party for the exploration of the Blue Mountains in Oregon. He expects to devote at least six months to the field work.

PROFESSOR A. F. VON WALDHEIM, of Warsaw, has been appointed Director of the St. Petersburg Botanical Garden.

THE Scientific Society of Danzig has offered a prize for a research on fungus epidemics in insects which are harmful to the forests. The thesis must be presented before the end of the present year.

THE State subsidy to the fresh-water Biological Laboratory at Plön, under the Directorship of Dr. Otto Zacharias, may be withdrawn next year. Several German societies are, however, urging the Ministry to continue the subsidy, and special subscriptions for the laboratory have been opened.

THE public meeting, which we have already announced, for the purpose of raising a fund for a national memorial to Edward Jenner in celebration of the centenary of his discovery of vaccination was held in the theater of the University of London, on March 31st. The chair was taken by the Duke of Westminster, who made some introductory remarks. Lord Herschell, the Chancellor of the University, proposed the first resolution, which was: "That the present is an appropriate time to inaugurate a work of national utility in honor of Edward Jenner." Lord Lister proposed: "That a subscription be set on foot with a view of promoting, in connection with the British Institute of Preventive Medicine, but in a manner distinguished by Jenner's name, researches on the lines which he initiated." Lord Lister intimated that the name of the Institute of Preventative Medicine might be altered to that of the Jenner Institute.

THE annual dinner of the Chemical Society, London, was held on March 31st, with Mr. A. G. Vernon Harcourt, the retiring President in the chair. Speeches were made by Lord Lister, Sir John Evans, Prof. Michael Foster and others. Professor Dewar is President-elect of the Society.

THE annual dinner of the Institution of Civil Engineers, London, was also held on March 31st. Mr. J. Wolf Barry presided and addresses were made by Sir F. Bedford, Mr. St. John Brodrick, Lord George Hamilton, the Lord Chancellor, and the Speaker of the House of Commons. According to the report in the London *Times*, the president stated that the institution was only about 70 years old, and even the name civil engineer was not very much more than 100 years old. The institution now numbered about 6,000 members, associate members and associates, and about 1,000 students, making in all an industrial army of about 7,000 persons. Their members labored in all parts of the world, and some of them were doing excellent pioneer work in the colonies. By a unanimous vote of the general meeting of the Institution held on the previous day a new departure had been taken. From the present time forward admission to the institution would be gained either by scientific examination or by the submission of some valuable paper or thesis. He thought that would be found of great value to the outside world, since it would be a guarantee that

a member of the institution wherever found possessed that amount of scientific knowledge on which all civil engineering must be based. It would also be of great value to the institution, raising it as a body to its proper position and enabling it to keep pace with those great developments of scientific research which were continually being brought to light.

A BILL before the German House of Representatives appropriates about two and a-half million dollars for rebuilding the hospitals and clinics of the University of Berlin, and about two million dollars for the establishment of the Botanical Gardens with its museum and the pharmaceutical laboratory at Dahlem.

THE interest of the Frohschammer fund of the University of Munich, amounting to $400, is offered for an essay on 'A Psychological Analysis of the Facts of Volition,' which must be presented before October 1st, 1899.

THE Academy of Sciences and Arts of Bordeaux offers a prize of $600 for a paper on the culture of fresh-water fishes.

THE University of St. Petersburg has received a gift of 100,000 roubles from M. Ssimin for a bacteriological observatory.

THE Boston Museum of Fine Arts receives $50,000 through the will of the late Miss Mary G. Morrill.

WE learn from the *Revue Scientifique* that the Geographical Society of Paris has awarded its gold medal to Dr. Nansen; the Ducros-Aubert prize, 14,000 frs. and a gold medal to Lieutenant Hourst for his expedition to the Niger, and gold medals to M. Flamand for his studies in the south of Algeria, to M. Versepuy for his expedition across Africa, to M. Chaffanjon for his journey from the Caucasus to Mandjourie, to commander Koch for his maps of French colonies, and to M. de Flotte for his map of Morocco.

THE library of the late Professor G. vom Rath, the mineralogist, has been presented by his widow to the University at Bonn.

DR. KUNO FISCHER, of Heidelberg, the well-known writer on the history of philosophy, celebrated on the 19th of March the fiftieth anniversary of his doctorate.

PROFESSOR A. BASTIAN has asked for leave of absence for another year from the University of Berlin to continue his anthropological investigations in the East.

ACCORDING to the latest reports there has been a decided decrease in the prevalence of the plague at Bombay, the number of deaths for the last week of which reports are at hand numbering only 360, with 323 new cases. Dr. Yersin reports that flies as well as rats play an important part in the dissemination of the plague.

IN the Bulletin of the American Museum of National History, Dr. J. A. Allen describes a new species of mountain sheep from the British Northwest Territory, which he calls *Ovis stonei*. It is very closely related to *O. dalli*, from which it differs chiefly in the darker coloration and restriction of the white to well defined areas, and, in fact, it would seem entirely probable that *O. stonei* may prove to be merely a subspecies whose darker coloration is correlated with its more southern and less elevated habitat.

THE Committee on Units and Standards of the American Institute of Electrical Engineers has recommended that Hefner-Alteneck Amyl-Acetate Lamps furnished with test certificates from the Physikalisch-Technische Reichsanstalt at Charlottenburg, Berlin, should be temporarily adopted as concrete standards of luminous intensity, or candle power. It ought not to be necessary to go to Germany for a photometric standard. The existence of the Reichsanstalt at Charlottenburg has an undoubted influence on the great increase of exports from Germany. Figures for 1896 are not at hand, but in the course of the preceding five years the annual exports from Germany increased in value by nearly $250,000,000, while in the same period those in England decreased to the extent of $100,000,000.

AT the annual general meeting of the fellows of the Royal Horticultural Society, London, it was reported that in order to celebrate the Queen's long reign the Council had decided to strike a special medal or medallion, to be called the Victoria medal of horticulture, and to be awarded *honoris causa* in the domain of horticulture. The Society has now £4,000 and wishes to increase this amount to £40,000 in

order that it may erect a horticultural hall in London.

ACCORDING to the London *Times* Sir Claude Macdonald has published, in China, a report from Mr. Bourne, of the British Consular Service there, on an extraordinary landslip on the banks of the upper Yang-tsze, which has created a new and dangerous cataract in that river. Mr. Bourne describes the cataract as being situated in latitude 30° 54′ 30″, and in estimated longitude 109° 16′, and about half a mile above a small rapid called Tachang. It is now much the worst rapid in the Yang-tsze, over which junks can only go empty and even so with the greatest danger. The rapid was formed at 10 p. m. on the 30th of September last by a landslip that occurred after 40 days of rain. While the water was high the extent of the obstruction was not apparent; as the river sank the rapid became impassable to upward-bound junks, and remained so for about a month. On the 4th of December the first upward-bound junk was hauled over, and there seems a great probability that as the river drops further the rapid will become again impracticable to the upward traffic. A block of ground, measuring 700 yards north and south by 400 yards east and west, has fallen down from the slope of the mountain on the north bank, a distance of 150 yards, reducing the breadth of the river from 250 to 80 yards.

IN France the manufacture of matches is a state monopoly and under state control, and in view of the numerous cases of illness among the workers and the many complaints which have been made in the press the Minister in charge has asked the Academy of Medicine to draw up rules for the regulation of the government factories. According to the *Lancet*, the Academy has agreed to the following answer being sent to the Minister: 1. It is necessary to put a stop to the unhealthy conditions which exist in many of the match factories in France. 2. The suppression of the use of white phosphorus is the only certain way of insuring health to the workers in this manufacture. 3. The employment of perfected automatic machinery is a costly matter and carries with it the condition that all dangerous operations should be done under glass. 4. Until these recommendations can be carried out as a whole the present unhealthiness can be diminished by thorough ventilation, short shifts for those men working in the dangerous shops, careful selection of healthy hands, and periodical medical inspection, with power to prohibit the labor, either for a time or altogether, of anyone with lesions of the mouth or whose general health is impaired.

UNIVERSITY AND EDUCATIONAL NEWS.

THE Medical College of the New York University and the Bellevue Hospital Medical College have been consolidated under the control of the New York University. The enrollment of students last year in the two schools was 1,057.

THE Sheffield Scientific School of Yale University receives $25,000 by the will of Mrs. Sarah Van Nostrand.

THE department of natural history of Vassar College will receive about $25,000 through the settlement of the will of the late Jacob P. Giraud.

A BILL before the Texas Senate appropriates for the State University $35,000 for 1897 and $85,000 for 1898, and in addition $42,000 annually for the medical department.

THE trustees of the Teachers' College have appointed Mr. George P. Krapp associate professor of the biological sciences, in conjunction with Professor F. E. Lloyd.

DR. BECKENKAMP, teacher in the Chemical School at Mühlhausen, has been called to the chair of mineralogy at Würzburg; Professor L. Claisen, of Aix, to the chair of chemistry at Kiel. Dr. Gaupp has been promoted to an assistant professorship of anatomy at the University of Freiburg. Dr. Boldinger has qualified as docent in analytical chemistry in the University of Amsterdam, and Dr. v. Buchka as docent in chemistry in the Polytechnic Institute at Charlottenburg.

PROF. V. KRIES, of Freiburg, has declined a call to the chair at Berlin vacant through the death of Du Bois-Reymond.

IT is proposed to take powers to transfer the

patronage of Edinburgh Royal Botanical Gardens to the Crown, and to unite the Regius professorship and the University professorship of botany.

DISCUSSION AND CORRESPONDENCE.

THE BRUCE ASTRONOMICAL MEDAL.

To the Editor of Science: Miss Catherine Wolfe Bruce, of New York city, to whom astronomy all over the world is indebted for liberal and intelligent benefactions, proposes to found a gold medal to be awarded not oftener than annually by the Astronomical Society of the Pacific for distinguished services to astronomy. The medal is to be international in character and may be given to citizens of any country and to persons of either sex. The design for the obverse of the medal is the seal of the Astronomical Society of the Pacific. The medal is to be 60 mm. in diameter. The reverse is to bear this inscription: "This medal founded A. D. MDCCCXCVII. by Catherine Wolfe Bruce is presented to—(name)—for distinguished services to Astronomy——(date)."

The Astronomical Society regularly awards also a bronze medal founded in 1890, by the late Joseph A. Donohoe, for the discovery of each unexpected comet.

Edward S. Holden.

Lick Observatory.

PROFESSOR SCOTT'S BIRD PICTURES.

In *Scribner's*, for April, Professor W. E. D. Scott 'scores the conventional method of bird-stuffing, and furnishes eight pictures of birds which are stuffed according to his own ideas.' Now, Professor Scott speaks from long experience, and what he says is largely, but by no means wholly, to the point, for much of our museum work *is* undoubtedly bad. Whether or not the pictures which illustrate the article and are held up as examples for us to follow are any great improvement over our more recent bird work is very questionable. It might seem ungracious to criticise these pictures of stuffed birds, but when our attention is called to them by aggressive italics and special postal cards criticism would seem to be invited. It therefore becomes a painful duty to say that the Clapper Rail and Robin are certainly not in conventional attitudes and that aside from these at least three of the birds are decidedly faulty, these, moreover, being birds with which Professor Scott should be most familiar. The Bittern, p. 503, is so poised that he seems about to topple over backward, while his neck and free foot are both wrong. Ward's Heron, p. 501, and the Little Blue Heron, p. 502, both have curves in their necks which, from the structure of their backbones are *physically impossible*. The shape and articulation of the neck vertebræ of herons is such that they *always* have more or less of an angular bend in their necks, whether these be extended vertically or doubled upon themselves, and failure to reproduce this very characteristic feature means failure to convey a correct idea of a heron. We may accept Professor Scott's strictures, but we decline to follow his models.

F. A. Lucas.

NOTE ON A SIMPLE METHOD FOR NEWTON'S TOTAL REFLECTION EXPERIMENT.

Demonstrators who have written for their fellows seem to have overlooked the fact that Newton's beautiful experiment, showing that for any pair of media each color having its own index of refraction has, therefore, its own critical angle, may be exhibited by much more simple and inexpensive means than the four prisms usually required for that purpose.

All that is really necessary beside the lantern or other means for getting a strong sharp parallel beam is a refraction tank, such as Wright's, having glass ends. If this tank is set up in the path of the beam in such a manner that the light may be made to pass obliquely upward into the water as for total reflection it will be found that, by adjusting the depth of the water in the tank and the angle of incidence of the beam, the apparatus can be so arranged that only red rays will emerge, all others being totally reflected. Now, by diminishing the angle of incidence of the pencil on the air surface, tilting the mirror if one is used, the remainder of the spectrum may be brought in order out of the water, and, by reversing the operation, sent back again totally reflected. Just as in the demonstration in which the right-angled prisms are employed, the image of the

slit formed by that portion of the pencil which at every incident angle undergoes reflection is tinted by the rays so sent back.

As in all such work, the sharper the beam the better the results, but I find the experiment succeeds very well indeed with the beam obtained by projecting with the ordinary optical front a narrow slit in the stage of my electric lantern.

F. W. MCNAIR.

MICHIGAN MINING SCHOOL.

SCIENTIFIC LITERATURE.

Annual Report of the Geological Survey of Canada for the Calendar Year 1894. G. M. DAWSON, C. M. G., LL. D., F. R. S., Director.

This volume is No. 7 of the New Series of Reports of the Canadian Survey, and comprises 1,206 pages, accompanied by eleven maps, fifteen plates and diagrams, besides figures in the text. It is a storehouse of facts relating to the geology of all parts of the Dominion, and is the first of the reports prepared by the guiding hand of the new Director.

The staff of this organization, including all employees, professional and ordinary, numbers fifty-one persons, and the total amount, expended sum up $110,000 for the fiscal year ending June 30, 1894. The several reports are, first a summary of all the operations by the Director; then an account of the geology of the Kamloops map-sheet in British Columbia, by Dr. Dawson; an exploration of the Finlay and American rivers in the north part of the same province, by R. S. McConnell; preliminary report upon the south part of the district of Keewatin, by D. B. Dowling; the geology of the southwest sheet of the eastern townships, by R. W. Ells and F. D. Adams; the surface geology of eastern New Bruswick, northwestern Nova Scotia and a portion of Prince Edwards Island, by R. Chalmers; upon the chemistry and mineralogy, by G. C. Hoffmann; upon mineral statistics and mines for 1893 and 1894, by E. D. Ingall and H. P. H. Brumell, and many paleontological notes interspersed here and there by J. F. Whiteaves and H. M. Ami.

Out of such a mass of information one can only refer to matters in which he is most interested.

At Athabasca landing, near the Canadian Pacific Railway, a trial boring has been effected to the depth of over 1,000 feet for petroleum. Beds of soft Cretaceous sandstones from 140 to 225 feet in thickness, for a distance of ninety miles along Athabasca river, are more or less saturated with bitumen. It is believed that the petroleum occurs in Devonian strata, which in the neighborhood underlie the Cretaceous. As the tar sands proved to be somewhat thicker than was expected, and various difficulties arose, partly in connection with the large supplies of gas exhaled, operations had not been completed at the time the report was made; and it was thought it would be necessary to continue this boring five hundred feet further before abandoning the location. The probabilities seemed ample for expecting the development of another oil field in this district.

The statistics of production of valuable minerals give a total value of $20,950,000 for the year 1894, which is a slight falling off from the yield of the previous year. The more valuable products in the order of their importance are coal, nickel, bricks, building stone and gold, the last having the value of $1,042,055. British Columbia produced the most, $456,066, followed closely by Nova Scotia. The Columbian mines are almost entirely worked in placers of Pliocene age, derived from auriferous veins in the Carboniferous and Triassic rocks. Dr. Dawson states that "British Columbia has now fairly entered on a period of rapid and thorough development of its mineral resources."

Perhaps with the idea of promoting this development, large space is given to the description of the geology of the Kamloops sheet, with a map descriptive of an area about eighty miles square, just above the latitude of 50° and comprised between longitudes 120° and 122°, through which the Canadian Pacific Railway takes its course. The aggregate thickness of the formations in this field is 79,500 feet. The Archean is wanting, though present just to the east of longitude 120°. The Cambrian consists of two parts: the lower, or *Nisconlith* series—dark argillites; and the upper, or *Adam's Lake* series—volcanic beds with arkose conglomerates; both amounting to 11,500 feet. The Silurian and Devonian have not

been recognized. The Carboniferous or *Cache Creek* series is 12,000 feet thick, one-third limestone. Its character is like that of the corresponding limestones and quartzites of corresponding age observed in our Fortieth Parallel Survey. The Triassic, or *Nicola* group, occupies a considerable area, with a thickness of 10,000 to 15,000 feet comparable with the rocks of the same age in Nevada. The materials are largely volcanic, diabase porphyrites becoming amygdaloidal; also agglomerates passing into diabase tuffs. The sediments are marine limestones and argillites. Certain limited areas are believed to be Lower Jurassic, though not separated upon the map.

Passing the Cretaceous development, the Oligocene Tertiary, or *Coldwater* group, is quite important, its materials consisting of aqueous deposits, conglomerates, sandstones and shales, in some places holding coal and lignite. None of the beds are marine, and all are said to be separated from the Miocene by unconformity.

Fully half the area of the map is occupied by the Miocene, which is composed of volcanic rocks over 9,000 feet in thickness. The lower division consists mainly of augite-porphyrites; the middle of fine-grained tuffs that have been laid down in water containing beds of lignite, perhaps of merchantable value, and the upper of basalts, melaphyres, etc., easily seen to have been ejected from numerous local vents. Fossil plants have been collected from all parts of the Cretaceous and Tertiary series, and serve for the basis of the stratigraphical reference and assignment.

The granites found in the Kamloops area are of medium coarseness passing from biotite-granite to hornblende-biotite granite, are sometimes foliated, especially near their contact with Paleozoic strata, and are probably post-Archean in age.

Perhaps the most interesting part of the volume is the description of the geology of the Montreal sheet by Dr. Ellis. This area lies between latitudes 45° and 46°, immediately north of the international boundary and between longitudes 72° and 74°. It is the first area studied carefully by the Survey, as it embraced the vicinity of Montreal, the chief city of the Dominion; and it is interesting to United States geologists because the formations pass from it into our territory. It has also great historic interest, as it has been the field of vigorous controversy.

Before 1860 it was supposed that its structure furnished the key to the solution of the metamorphic problem of eastern America. Studies by Sir William E. Logan furnished the foundation for a peculiar paleontology, which referred the terranes southeast from the St. Lawrence to the horizon of the Chazy-Calciferous; some of these had, in the previous decade, been referred to the Medina or Middle Silurian. Because of the accurate stratigraphical and paleontological studies of this area, it was claimed that the extension of the terranes southerly defined the age of the crystallines of New England, all of them being Silurian or Devonian. The Vermont Geological Survey had accepted these Canadian conclusions, fortified, as they were, by the opinions of Professor James Hall. But the Vermonters could not accept Logan's intepretation of the structure of the Green Mountains as they continued into Canada. Logan called it the 'Danville and Sutton Synclinal;' whereas on the southern side of the boundary line no interpretation of the dips could justify any such structure. In the midst of these perplexities of adjustment there came, at the end of the year 1860, a communication from Sir W. E. Logan containing a letter from Barrande affirming the primordial (Potsdam) age of the trilobites referred by Hall to the Hudson River group, and the consequent abandonment of a belief in the Silurian age of the Olenellus slates. Much readjustment of the details has been required, and it is only now, thirty-five years after the publication of Barrande's letter, that the details are properly presented. Instead of the 'Danville and Sutton synclinal' Dr. Ellis gives us the 'Sutton mountain anticline,' and there are broad expanses of pre-Cambrian and Cambrian terranes to take the place of the former Middle and lower Silurian. This pre-Cambrian Green Mountain area is about twenty miles wide at the international boundary, flanked on both sides by a Cambrian terrane and there by the Cambro-Silurian. On the west side the Calciferous sandrock seems to be absent be-

tween the Cambrian and the Chazy-Trenton limestones of Farnham. On the east side the Cambro-Silurian succession involves the reference to a lower horizon than has been commonly accepted, of the micaceous limestones which pass into the group termed the 'Calciferous mica schist' in the Vermont and New Hampshire reports. This reference is based upon discoveries of graptolites about Lake Memphremagog clearly of the age of the lower Trenton.

In the St. Lawrence plain country there are very few strata referred to the upper Silurian; but on the Memphremagog side well-defined Niagara and Devonian fossils are abundant.

This area has also afforded much material for petrographical studies in the series of bosses and eruptive masses of diorites, diabase, syenites and late granites extending from Stanstead across the whole sheet to the Laurentian gneisses and anorthosites of the northwest corner back of Montreal, a part of the original Laurentian area of Logan. The anorthosites are now clearly understood to have had an eruptive origin; and hence the original conception of an upper Laurentian or Labrador system of stratified rocks is abandoned.

The Dominion of Canada now furnishes us the most important field for the study of glacial phenomena. By slow degrees the existence of an outer margin and various terminal or recessional moraines has been proved for the United States; and it remains needful to explore the districts farther north up to the Arctic regions in order to find additional moraines and the starting points of the ice movements. Dr. G. M. Dawson, the Director of the Survey, has given names to two parts of what has been called the continental ice mass. One is the *Laurentian* and the other the *Cordilleran* glacial sheet, each with an independent existence, but sending out ice streams which have coalesced in the great western plains. The Cordilleran mass was somewhat the smaller of the two, having at its maximum development a length of 1,200 miles. The main gathering ground or *névé* of this ice sheet lay between Latitudes 55° and 59°; and the ice flowed northerly, into Alaska 350 miles, westerly into the Pacific Ocean, southerly as much as 600 miles, into the edge of the United States, and southeasterly over peaks rising to altitudes of over 7,000 feet; thus implying a thickness of over 6,000 feet above the principal depressions of the surface. Dr. Dawson thinks there were two maximum periods of glaciations in the Cordilleras, followed by subsidences, in the first case 500 and in the second to 2,500 feet below the level of to-day. There are numerous terraces of boulder clay and white silts corresponding to these levels. Indeed, judging from the descriptions and views of these high terraces, there is nothing comparable with them anywhere else upon the continent.

From the report of Mr. Low it would appear that the central part of the Labrador peninsula was the gathering ground of the Laurentian ice sheet, from which glaciers flowed off in all directions, notably to the west, east and south. The striæ indicating the westerly movement are the least distinct.

Mr. Robert Chalmers reported upon the surface geology of the maritime provinces. He finds evidence of ice movements northerly and easterly from the higher elevations in northern New England and Quebec, as well as southerly in the St. Johns valley. No ice reached the peninsula of Nova Scotia from the mainland except to a very slight degree; and the glaciation effected is explained by supposing radial movements from the Cobequids and the watershed of the main peninsula. The general conclusion drawn is that there was no movement from the St. Lawrence valley up and over the New England highlands towards the sea. All the phenomena are to be explained upon the theory of local glaciers moving outwardly to all quarters of the compass from the greater mountains. Instead of our going to Canada for the source of the New England glaciation, the Canadians now come to the White and Green mountains in search of the ice which brought débris into the St. Lawrence valley. The writer would remark that these conclusions are undoubtedly correct for one of the later epochs of glaciation. The glaciers of the Champlain age entering the St. Lawrence valley, both from the Labrador peninsula and the New England summits, brought icebergs which floated over Montreal and Quebec and induced the severe climate, lasting for a long time, which was suitable for the habita-

tion of the boreal mollusca. For this reason the till of the lower St. Lawrence valley seems to have been deposited under marine conditions, covering up all the marks made by the earlier ice sheets. Hence it is not strange that the Canadian geologists have so generally given the largest place to icebergs in their conceptions of the work done in the ice age.

The perusal of this volume clearly shows the great efficiency of the Director and his assistants in carrying on the work so ably commenced by Logan and Selwyn. The field work has been carried on economically and successfully. While theories of divers kinds are advocated, there seems to be no attempt to distort the facts to square with preconceived notions, and all will hope that abundant means will be continuously supplied to the survey organization to carry on its explorations in a manner honorable to the Dominion government.

C. H. HITCHCOCK.

Tables for the Determination of Minerals by Physical Properties ascertainable with the aid of a few field Instruments based on the system of Prof. Dr. Albin Weisbach. By PERSIFOR FRAZER. Lippincott. 1897. 4th edition enlarged, 163 pp.

The first edition of this book appeared in 1874 and has been followed by the succeeding editions at varying intervals (1877, 1891, 1896).

This is really an authorized translation of the German work of Weisbach, to which Professor Frazer added the empirical formulæ best representing the data at hand. Few changes were made till the publication of the third edition which appeared rewritten and considerably changed in detail, though following the lines laid down in the first edition. The chemical formulæ previously used were replaced by those given by Groth in his 'Tabellarische Uebersicht der Mineralien,' and to the tables were added the characteristic habit, structure, fracture, specific gravity and association of the minerals.

The present edition is an enlarged and corrected reprint of the preceding. To the seven hundred and sixty odd species and subspecies previously included, there have been added a hundred and thirty-five others, which embrace several old and well known species, like microcline, and many minerals which recently have been described or rendered of economic importance, like monazite.

As in the earlier editions, the only instruments necessary are a knife, streak table, file and pocket lens. The classification is based on the lustre, streak and hardness, thus dividing the minerals into sixteen different classes upon criteria which are easily determined by the practical manipulator. The book is intended to be of service to the student, as an artificial aid to memory; to the field geologist, as a reminder and handy book of reference for properties of unusual minerals; and to the amateur, as an incentive to more accurate observations.

The author, for the sake of economy, in using the old electrotype plates, has, in a measure, decreased the value of the book, as their use has caused the retention of features which to-day savor of an earlier period in mineralogy. At the present time there is a tendency to discard even the well known crystallographic symbols of Naumann in favor of the Miller system. The present book, however, retains the abbreviated Naumann symbols suggested by the elder Dana, without incorporating the modifications introduced in the last edition of E. S. Dana's Manual of Mineralogy. A still more pronounced archaism is the introduction of such 'mineral species' as *pitchstone* and *perlite* which belong to rocks and not to minerals. Similar criticism might be passed on the ambiguous use of the term 'andesite,' which on page 92 is used to designate a mineral, while on page 99 it designates a rock; or the term *pegmatite*, which is given as a varietal name for orthoclase.

Turning to the tables themselves, there seems to be looseness in the choice of values given for hardness and specific gravity; the habitat or association of the minerals, and the symbols used as abbreviations.

In turning over the pages, the eye catches such deviations from the hardness, as on page 90, where the opal is ranked as '5' (Dana 5.5.–6.5), or the separation of 'andesite' on page 92 from laboradorite on page 100 (both 5–6). The choice of values for density may be illustrated by those given in the mica group, where the higher limits seem to be preferred,

though micas generally give lower values than the true on account of their crystal habit. For example, Lepidolite 2.9 (2.8–2.9), biotite 2.9 (2.7–3.1), muscovite 3. (2. 76–3.), phlogopite 2.9 (2.78–2.85).

In spite of these slight deviations, which undermine one's faith in the accuracy of the book, there is little doubt that the tables will prove serviceable to the practical worker who wishes to gain at a glance the approximate values of the substance under investigation.

The typography of the book is good, the type is clear, and the matter is well spaced. An especially attractive feature is the size, which is adapted to the collecting bag or pocket. The few instruments required, the use of the external and physical properties only, the notes on the paragenesis, and the great number of rarer minerals, will make it serviceable alike to the field geologist, the mining engineer and the teacher.

E. B. MATHEWS.

Traité élémentaire de mécanique chimique, fondée sur la thermodynamique. P. DUHEM. Paris, A. Hermann. 1897. Vol. I. Large octavo. Pp. viii+299. Price, 10 francs.

The object of this book is to give a consistent, coherent account of the mathematical theory of the changes in physical state and chemical constitution, as obtained by an application of thermodynamics. This would be valuable even if badly done, since the mathematical treatment of physical chemistry in book form is painfully deficient in comparison with the exhaustive handling of the experimental side of the subject by Ostwald. This particular book is doubly valuable because it not only gives us the mathematical development of the subject, but presents it in a masterly way.

Duhem begins with a short sketch of the analytical methods to be used, and then develops the fundamental principles of thermodynamics, taking up in order the conservation of energy, the first law of thermochemistry, the theorem of Carnot-Clausius and the absolute temperature, the entropy and the thermodynamic potential, the general equations of thermodynamics, the application of the thermodynamic potential to systems at constant pressure or constant volume, perfect gases, isothermal displacement of equilibrium, heat effects, adiabatic displacement of equilibrium and the change of the equilibrium with the temperature. The remarks on the accuracy of Hess's law, page 49, are especially worth reading because the points raised are usually overlooked in the statement of the theorem.

The second part of the volume—devoted to false equilibria and explosions—is even more interesting than the first part because the point of view is less familiar. Duhem has been troubled like many others by the fact that in certain cases there was a state of equilibrium when the theory, as formulated, said that this was impossible. Gibbs showed that many of the difficulties could be removed by the assumption that the surface of a phase was in a different state from the interior—in other words, by the theory of capillarity. Duhem attempts to carry this farther by introducing the notion of viscosity or of false equilibrium. His idea can best be understood by an analogy from mechanics. Suppose we have a body on an inclined plane. In an ideal state of things where there is no friction the body is not in equilibrium and will slide down the inclined plane. In the world as it is we can not get rid of friction entirely and the body will remain stationary on the plane, provided the pitch is not too great. Similarly, if there were no passive resistance to change, water vapor and a mixture of hydrogen and oxygen in the proportions in which they combine to form water should yield the same system under the same conditions. At low temperatures this is not the case experimentally, so far as we now know; so that it is natural to follow out the analogy and to say that in the actual chemical world there is a chemical friction or chemical viscosity and that states of equilibrium are thus possible which could not occur in a system where there were no passive resistances to change.

Duhem now attributes to capillary phenomena the behavior of supercooled vapors and superheated liquids, and he is inclined to group under this head supercooled solutions, supersaturated solutions and some theoretically unstable solid allotropic forms, classifying under false equilibria hydrogen and oxygen, liquid

phosphorus, silicon trichlorid and many other substances. It is a question whether this is justifiable. It seems irrational to put rhombic and monoclinic sulphur in one class and the two modifications of phosphorus in another; but it is certainly interesting, and the application of his theory to the point of reaction, to reaction velocities and to explosions deserves careful attention. It will interest many to note that Duhem's view of a mixture of hydrogen and oxygen as being actually in equilibrium at low temperatures is not reconcilable with the Ostwald-Nernst idea that it is not a case of equilibrium at all, but rather of immeasurably low reaction velocity. A fairly strong argument can be made out for either view, and the scientific world owes thanks to Duhem for making the question a live one.

WILDER D. BANCROFT.

Trigonometry for Beginners. REV. J. B. LOCK, M. A. Revised and enlarged by JOHN A. MILLER, A. M., Indiana University. New York, The Macmillan Company. 1896. 200 pp. Price, $1.10.

Trigonometry, of all elementary branches of mathematics, might easily substantiate its right to be considered the most congenial and popular subject that necessarily claims the attention of engineers and practical men, otherwise but little inclined to sympathize with the purest in the science. Led on by its numerous and interesting applications, many a student, without being aware of it, has taken his first step in the theory of functions, acknowledged the results to be fascinating as well as eminently practical, and gone his way to rail at the higher theory, quite unconscious of the spectacle he thereby makes of himself. The natural result of this favoritism has been a steady improvement in the quality of the text-books produced in trigonometry until such works as that of Chauvenet and, to mention a less ambitious book, that of Wells, challenge competition successfully for a series of years.

With a new edition of Lock's Trigonometry, The Macmillan Company enters the field, and with its usual business sagacity have secured its revision by an American. Professor Miller has certainly earned the right to have his name on the cover, indeed, because of additions and improvements far less necessary and fundamental many a man would have called the volume his own. As claimed, the new edition corrects the fundamental weakness of its predecessor by carefully emphasizing the necessity for proofs for all relations, especially for the addition formula, that are rigidly correct for all values of the angles involved. To this end, as is necessary, we find clear demonstrations of such relations as, for example, $\sin(90° + A) = \cos A$ for all values of A. This enables the author in §79, while attempting to generalize the addition formula, to write.

$$\sin[90° + (A' + B)] = \cos(A' + B),\ 0 < A' < 90°,\ 0 < B < 90°.$$

He then remarks since A' and B are now both less than 90° we may write

$$\cos(A' + B) = \cos A' \cos B - \sin A' \sin B. \quad (\S 76).$$

There is certainly a flaw in the general accuracy of the argument up to this, the pivotal point of trigonometric analysis, for § 76 does not completely justify this expansion, since the demonstration to which reference is made depends upon a figure representing both A' and B, as in the first quadrant, and their sum also as in the first quadrant, whereas, in the case before us, we have no means of knowing whether $A' + B$ is greater or less than ninety degrees. In fact, before analytic demonstrations for particular cases can be accurately defended, geometric demonstrations must be given for $0° < A < 90°$, $0° < B < 90°$ for the four possible cases under this head, namely,

$$(A + B) < 90°,\quad (A + B) > 90°,\quad (A - B) > 0°,\quad (A - B) < 0°.$$

On the other hand, it must be admitted that the author, in paragraph seventy-eight, calls attention to the fact that a similar construction will apply to all possible cases, and even gives a third example, different from either, of those that are necessary. The criticism is, however, that, since up to this point unusual effort has been made to demonstrate the addition theorems, this is certainly not a good place to leave necessary steps to the student.

Like most English text-books, the present

volume is very rich in illustrative examples carefully and admirably adapted to meet the requirements of both teacher and student. Indeed, this feature of the book will be its strongest recomendation to many practical teachers. In revising the work Professor Miller has placed Chapter VII., which, in the old edition, followed Chapters VIII. and IX. in its logical position, and by thus developing first the Cartesian system of coordinates has succeeded in making the results of the later chapters general. To this portion of the text other tables might be added to some advantage, for example, one tabulating the values of functions of angles that are multiples of five, and one giving an expression for each function in terms of the others. While of undoubted worth as a means of reference, such tables, it might be argued, are of doubtful value from a pedagogic standpoint. At least they should be required to be established by every student of trigonometry, and it would have been well to have required them among the examples. The book is also unique in respect to the absence of the time-honored figures illustrating the positions and comparative lengths of the functions other than the sine and cosine in the different quadrants of a circle whose radius has been assumed as the unit. Here, again, the omission may be defended on the ground that nine students out of ten, having these figures for the special case in mind, will carry to the grave the impression that the functions are lines instead of ratios. Nevertheless, they are of value in mechanical drawing, and especially as affording a ready means of prompting the memory in the thousand and one simple relations they illustrate, and by constant emphasizing of the ratio definitions on the part of the teacher they can be used without confusion of ideas.

The added chapter on inverse functions, and the one that has been much improved on the solution of trigonometric equations, are valuable and essential parts of the new edition, the importance of which will not be underestimated by the advanced student of mathematics. Finally the analytic portion of the plane trigonometry is completed by the establishment of the so-called tangent formula, $a - b : a + b = \tan \frac{1}{2}(A - B) : \tan \frac{1}{2} A + B)$, by a direct development from the rigidly demonstrated addition theorems. Many of the old treatises prove this formula, probably because of its importance, geometrically, and lose thereby in generality. The geometric proof is of exceeding interest, however, and the present demonstration would be emphasized and the book gain in pedagogic strength were it given in a foot-note with a corresponding valuable reference to its limitations.

In outline the design of the book is to discuss, in the first thirteen chapters, the general theory of the trigonometric functions; then, in chapter fourteen, to give a short review of the theory of logarithms followed by a discussion of the solution of the triangle, and, finally, by two short chapters giving applications to engineering and geometrical problems. This is the time honored arrangement, certainly in the hands of a good teacher sufficiently effective. As our author says, "the discussion of logarithms belongs properly to algebra," and as a rule the student has met with them during the preceding term's work, but has, nevertheless, far from mastered their application and still less their theory. Why not then begin at once with a review of the theory of logarithms and insure a thorough mastery of their application by constant practice from the beginning? While the student is learning about angular measurement and the trigonometric ratios the class can be exercised in the evolution of complicated numerical expressions and in the solution of logarithmic equations, and, as soon as the functions are developed, a large number of the applications to right triangles reserved for the last chapters may be discussed immediately, affording new material for logarithmic work, thus arousing at the start the keen interest of the practical mind.

The last thought has been acted upon by the author. Pages 10, 11, 26 and 27 are filled with practical problems of a most interesting character, all of which, however, are intended for solution without the aid of logarithms. Finally Professor Miller has added two short chapters, in which he develops the theory of the solution of spherical triangles. Here, as in the plane trigonometry, the author is fully alive to the limitations of geometric proof and care-

fully renders the fundamental formula $\cos a = \cos b \cos c + \sin b \sin c \cos A$ perfectly general, and then by basing all further deductions on this one determines rigorously all necessary relations.

To some teachers it may seem that on this feature of the work too much emphasis is laid, and that too much time, and, possibly, clearness and definiteness are sacrificed to this end. On the other hand, the careful student will maintain that this one feature should recommend the book most highly, for long after the pupil has forgotten what a cosine is he will have retained the habit of mind which distinguishes clearly between the general and the particular, and will be less apt to make that most frequent of all mistakes in logic, that of arguing to the former having proved the latter. Certainly, if the present criticism is at all just, enough has been said to put in evidence the fact that Professor Miller has succeeded, at important points, in improving Lock's trigonometry, and his work will assuredly be found acceptable to many educators.

So far as the publishers are concerned, the typographic results are excellent; different types have been employed with useful discrimination, and a cheerful appearance is given through liberal use of space. The book, however, is, for practical use, large. It contains two hundred pages, is heavier than Chauvenet, while containing only one-fourth as much subject-matter, and three times as heavy as Wells, while, save for some sixty pages devoted to logarithmic tables of questionable value, it does not contain any more. The student of Lock's text book in its present dress will certainly receive the impression that trigonometry is a very large subject indeed, and the probabilities are that he will never entirely recover from this, his first impression.

J. B. Chittenden.
Columbia University.

SCIENTIFIC JOURNALS.

THE ASTROPHYSICAL JOURNAL, MARCH.

Résumé of Solar Observations Made at the Royal Observatory of the Roman College During the Second Half of 1896: By P. Tacchini. A general summary of solar observations, giving the distribution in latitude of spots, faculæ and prominences during the period indicated.

Oxygen in the Sun: By Arthur Schuster. In a short note Professor Schuster calls attention to the close agreement in wave-length between two of the triplets of the 'compound line spectrum' of the oxygen and two of Young's chromosphere lines. In view of the recent opening of the question of the existence of oxygen in the solar atmosphere, Professor Schuster suggests that an accurate determination of the chromorpheric lines in question be made.

The Yerkes Observatory of the University of Chicago—I. Selection of the Site: By George E. Hale. The writer gives a review of the considerations that led to the selection of the site of the Yerkes Observatory. A general discussion of the points to be considered in the selection of an observatory site is followed by a discussion of the conditions to be met in the case in hand.

Preliminary Table of Solar Spectrum Wavelengths: By Henry A. Rowland.

On the Occurrence of Vanadium in Scandinavian Rutile: By B. Hasselberg. The paper describes the detection of the heretofore unsuspected existence of Vanadium in Norwegian and Swedish Rutile. The research was entirely spectroscopic.

A New Formula for the Wave-lengths of Spectral Lines: By J. J. Balmer. The author discusses a generalization of his formula for the hydrogen spectrum. This formula, which is generally known under the name of 'Balmer's law,' is $\lambda_n = 3645.6 \frac{n^2}{n^2-4}$. By introducing a new constant c, we have $\lambda_n = a \frac{(n+c)^2}{(n+c)^2-b}$, which is found to satisfy the series of lines hitherto investigated by Kayser and Runge by the aid of the formula $\frac{1}{\lambda_n} = A - \frac{B}{n^2} - \frac{C}{n^4}$. Balmer's new law is similar to that due to Rydberg, except that the latter considered the value of $\frac{b}{a}$ to be constant for all elements. Several geometrical constructions based upon the formulæ are given.

Minor Contributions and Notes, Reviews of Recent Astrophysical Literature.

Bibliography of Recent Astrophysical Literature.

SOCIETIES AND ACADEMIES.

BIOLOGICAL SOCIETY OF WASHINGTON—273D MEETING, SATURDAY, MARCH 13.

A PAPER by R. T. Hill and T. W. Vaughn on 'The Lower Cretaceous Gryphæas of the Texas Region' was presented by Mr. Vaughn. He spoke of the abundance of the individuals of this genus and their value in determining the location of artesian wells, the various species being characteristic of certain strata. He traced the phylogeny of the species and dwelt at some length on their involved synonymy.

Chas. F. Dawson spoke of the 'Dissemination of Infectious Diseases by Insects,' instancing the manner in which tuberculosis, swine plague, Texas fever and anthrax could be thus spread. The speaker described his own experience with flies, stating that from their habits they were particularly liable to convey disease.

Under the title, 'The Type (?) of a New-Old Species,' William Palmer spoke of the confusion which existed in regard to certain genus of birds, stating that while Linnæus had originally given a specific name to what he believed to be a cosmopolitan species, he had subsequently admitted a second species, based on a plate, while another author had described a third from still another plate. There was no type existing of any of these, while the authors of the second and third species had no specimens when they established their names. Mr. Palmer stated that two distinct birds had been confused under the three names, and that he proposed to separate them, basing his description on a bird which he had selected among numerous specimens. Would this specimen, to which a binomial name and definite description were attached for the first time, be a type?

Sylvester D. Judd, in a paper entitled 'Sexual Dimorphism in Crustacea,' limited himself to the *Amphipoda*. He stated that while in certain genera the males and females were very similar, there were other genera where secondary sexual characters were so marked that different sexes of the same species might be thought by the casual observer to belong to different genera. The anterior and posterior parts of *Amphipoda* are the parts that present secondary sexual characters. The antennæ are particularly subject to variation; in some species the inferior antenna is several times as long in the male as it is in the female. In other species the caudal end of the body of the male is monstrously developed. The hairs that occur on the anterior and posterior parts of the body are differently disposed, thus only in the males of *Byblis* do the antennal hairs form brushlike tufts, and in a number of other genera the hairs on the antennæ of the males are modified into elaborate sense organs called calceoli. It appears that the parts of the body of *Amphipoda* which exhibit secondary sexual characters often coincide with those parts upon which specific differentiæ are founded.

F. A. LUCAS,
Secretary.

ZOOLOGICAL CLUB, UNIVERSITY OF CHICAGO, MEETING MARCH 4.

I. *Cleavage of the Egg of Arenicola.* The cleavage belongs to the type known as 'spiral,' or better oblique. There is considerable yolk in the egg and it is almost evenly distributed before segmentation. In the four-cell stage there are three smaller cells and one very large one representing nearly half the entire egg. All the cells contain yolk. The two 'cross-furrows' on the upper and lower poles of the egg are parallel and are formed by the blastomeres B and D; the cross-furrow at the lower pole is much longer than the other, however, and is perfectly constant up to a stage shortly before the closure of the blastopore, thus affording an invaluable means of orientation. The future median plane passes at right angles to this furrow and thus forms an angle of 45° with each of the first two cleavage planes. The upper pole forms the anterior end and the lower pole the posterior end of the worm.

Ectoblasts, mesoblasts and entoblasts are formed in the usual way. The cells X and M (vid. Wilson, Nereis) are by far the largest cells in the egg. Primary trochoblasts, sixteen in number, arise from first quartet and are supplemented later by three cells from each of the small micromeres of the second quartet, which complete the prototroch except dorsally, where a break is left. Through this space four cells, derivatives of the first quartet, pass and come to lie posteriorly to the prototroch. The

first bilaterally symmetrical division in the egg (58-cell stage) is the fourth division of the blastomeres of the first quartet, viz., the formation of the apical cross of eight cells. There are no head-kidneys, and the cell corresponding to the nephroblast remains on the surface as a small, inconspicuous ectodermal cell.

The ventral or somatic plate grows as in *Amphitrite*. The second bilaterally symmetrical division in the egg is the third division of the large posterior cell (X). A smaller cell is given off anteriorly and lies across the median plane. The somatic plate broadens laterally and posteriorly, the lateral portions growing posteriorly faster than does the central portion, so that finally the cells along the posterior edge begin to meet in the median line just dorsal to the blastopore. The point where this concrescence begins is the point where the paratroch appears. This organ is formed from derivatives of X, but by an entirely different set of divisions from those which take place in *Amphitrite*, according to Dr. Mead's very kind personal communication. Within the paratroch are enclosed certain small cells which later become the proctodæum.

The first bilaterally symmetrical division of the mesoblast occurs at the seventy-cell stage. In the entomeres a fifth quartet is formed and the three cells of the fourth quartet divide bilaterally. No further divisions occur before the closure of the blastopore.

The first bilateral division, in the small ectomeres, in the large X cell, in the mesoblast and in the entomeres all occur at very different periods in development but in the *same generation of cells*, viz., the eighth, counting the unsegmented egg as the first.

Gastrulation is a combination of invagination and epiboly. The mesoblast shows the first sign of invagination; then the entomeres also elongate inward until they form a column extending to the ectoderm of the upper pole. Now the ectomeres overgrow their lower surface from the sides and ventrally, forming a triangular blastopore with its short base directed ventrally. The cells forming the lateral and ventral lips of the blastopore are twelve derivatives of the third quartet of ectomeres and later form the stomodæum. The proctodæal region should probably be regarded as a part of the blastopore, for it is originally continuous with the rest of the opening. It becomes separated from the stomodæum by the postero-anterior concrescence of the somatic plate. The gastrula is bilaterally symmetrical and its axis corresponds to none of the principal axes of the adult.

During the closure of the blastopore the mesoblast bands are forming in the interior of the egg. In this case we have an actual change of the plane of the mesoblast bands through nearly 90°, *i. e.*, from nearly dorso-ventral to longitudinal. The first cells of the bands are given off almost ventrally, but with each successive division of the mesoblasts the direction of the spindle is more nearly longitudinal with respect to the egg, until finally the cells of the bands arise anteriorly from the mesoblasts.

A word concerning the cleavage of *Sternaspis scutata* may be added here. This was worked out as far as the 80-cell stage by the author of this paper and corresponds, cell for cell, with that of *Arenicola*, differing, however, as regards size and structure of blastomeres and order of their formation. Sixteen relatively large cells corresponding to the primary trochoblasts of *Arenicola* are formed, but *Sternaspis* possesses no prototroch and these cells form part of the ectoderm.

II. *The Oblique Cleavage and its Relation to the Mosaic Theory.* After a review of the positions held by Roux, E. B. Wilson, Driesch, Hertwig, etc., the following arguments were given against the mosaic theory as applied to the oblique cleavage.

1. The failure of cell-homology in a rapidly increasing number of cases.

2. The very different size and structure in different species of blastomores which have the same normal fate.

3. Experimental work. Professor Wilson and Mr. Crampton err in regarding the experiments of the latter on *Ilyanassa* as supporting the mosaic theory, for in most cases 'regeneration' occurs. Mr. Crampton himself states in the text that in ½ and ¼ embryos the endoderm cells are *completely* overgrown by ectoderm, and also gives figures illustrating the same fact. It is, of course, impossible for ectoderm cells, which normally cover only the outer surface of cer-

tain endoderm cells, to overgrow in the ½ and ¼ embryo all sides of these cells and thus completely enclose them, unless 'regeneration' or 'postgeneration' occurs. Consequently Mr. Crampton's so-called ½ and ¼ embryos have at least made an attempt to become whole embryos, and Crampton and Wilson are wrong when they state that the power of 'regeneration' or 'postgeneration' is entirely absent.

A number of other points in this work were mentioned as affording evidence against instead of for the mosaic theory, even as modified by Wilson.

In general terms, the oblique cleavage is, of course, the result of the organization of the egg. It may be pointed out that it is the form of cleavage which brings each cell into contact with the greatest number of other cells. It is certainly not 'mechanical' in Wilson's sense, for even the constant direction of obliquity cannot be explained in this way.

O. Hertwig's view of the organization of the egg cannot be regarded as sufficient to explain the facts. Examples were given showing the extreme differences in the allotment of yolk in different species even when the yolk was similarly placed in the unsegmented egg. There is an organization more fundamental than the visible one, which governs both the form of cleavage and the position of yolk in the blastomeres.

The egg appears to be a complex of substances possessing the power to produce an embryo and through this an adult, by a series of processes not as yet understood. Visible localization in the egg or early cleavage stages, which is only a localization of protoplasm and deutoplasm, does not necessarily imply a corresponding location of the morphogenetic factors. The facts rather appear to indicate that what we call the morphogenetic factors are the processes going on in the egg as a whole. Any strictly cellular theory of development must be inadequate, as Dr. Whitman has shown.

In the final analysis the organization of the egg is dependent on the structure of the 'idioplasm.' This would seem to favor Dr. Whitman's view that the egg has a definite organization from the start. The localization of protoplasm and deutoplasm, however, which we find in the mature egg must be acquired during ovigenesis.

C. M. CHILD.

TORREY BOTANICAL CLUB, MARCH 9, 1897.

THE Secretary announced the conditions of a grant now offered from the funds left by Professor Newberry for encouragement of research, to be supplied successively to zoology, botany, geology and paleontology. For the present year the award is offered in geology or paleontology to amount to $50.00, payable July 15, 1897, the competitors to belong to the Scientific Alliance of New York City.

The scientific program was then taken up, the evening being devoted to the subject of ferns, with papers as follows:

1. Mrs. Elizabeth G. Britton, 'Notes on some Mexican Ferns,' presented in Mrs. Britton's absence by Dr. Rusby, with exhibition of numerous specimens, including species of *Pellæa*, *Polypodium*, *Cystopteris* and *Cheilanthes*. Dr. Rusby, having been himself present at their collection, described vividly the tongue of hard, black lava on which the collectors walked, and which was filled with large cavities often forming caves, containing some accumulation of soil and crowded with a luxuriant growth of ferns, although in November and practically the winter season.

2. Mr. Willard N. Clute, 'The New York Stations for *Scolopendrium*.' Mr. Clute contrasted the wide distribution of the Hart's-tongue fern in the old world, from the Azores to Japan, with the extremely local North American occurrence, in five areas only, Mexico, Tennessee, central New York, Owen Sound, in Ontario and New Brunswick. The central New York locality was made known early in the present century through John Williamson, and was visited by Pursh in July, 1807, who found it five miles west of Syracuse on the farm of J. Geddes, where it has recently been rediscovered. About 1827 Wm. Cooper discovered it at Chittenango Falls, where Mr. Clute found hundreds of plants growing last summer. Mr. Clute described the Chittenango ravine and its ferns. On sunny exposures of the limestone walls of the ravine grow rue spleenwort and purple cliff-brake in

quantities; in shady places the slender cliff-brake; on the talus upon the larger bowlders the walking fern, and in the shade of these bowlders the Scolopendrium, chiefly in clusters of 2 to 6, at first erect, finally somewhat drooping, and ripe in September. Mr. Clute added that the species seems to be increasing at present, being now under the protection of an association.

3. The third paper was by Mr. B. D. Gilbert, of Utica, N. Y., entitled 'New and interesting Ferns from Bolivia,' with exhibition of specimens of two new ferns, a species of *Blechnum* and a new variety of *Nephrodium villosum*, the first peculiar in being fully pinnate, the second in being a one-sided dwarf persistently under a foot and a half high, instead of 4 or 5 feet as its type.

4. The fourth paper, also by Mr. Gilbert, 'Jamaica, the Fern-Lover's Paradise,' described the abundance of species and of individuals which the speaker had collected there, illustrating the subject by numerous specimens. He remarked that Swartz in his *Species Filicum*, 1783–6, enumerating all then-known ferns, described 709 species, of which 149 were from Jamaica; the Jamaican number was raised to 300 by Grisebach and now to 500 by resident botanists there, an estimate confirmed by Mr. Gilbert. Probably no other equal area produces half that number. Among reasons which account for this are the warm latitude of Jamaica, its south shore sheltered from cooler breezes by a mountain wall, its mountains themselves rising to 7,000 feet and reaching into a cool temperature climate, and its great variation in moisture, with daily rains in the mountains and sometimes but twice in six months on the plain.

Edward S. Burgess,
Secretary.

BOSTON SOCIETY OF NATURAL HISTORY.

A general meeting was held January 2, 1897; forty-three persons present. Professor W. O. Crosby gave an account of the dike-like masses of sandstone that occur in the granite of the Pike's Peak massif in the Ute Pass, Colorado. For an Abstract see Science, page 604 above.

The Society met February 3d; one hundred and six persons present.

Mr. William C. Bates spoke of Venezuela and British Guiana, giving a brief historical account of their discovery, and describing, with the aid of a series of stereopticon views, various points of interest connected with their natural history, scenery and people.

Samuel Henshaw,
Secretary.

THE ACADEMY OF SCIENCE OF ST. LOUIS.

At the meeting of the Academy of Science of St. Louis held on the evening of April 5, 1897, Professor Frederick Starr, of the University of Chicago, briefly addressed the Academy on the functions of such organizations, with especial reference to local problems. Mr. H. C. Irish presented a paper on the relations of the unfolding of plants in spring to meteorological conditions, in which were embodied deductions drawn from a series of observations made at the Missouri Botanical Garden, and those by other observers, extending back to the time of Stillingfleet, in the last century. Mr. Charles Robertson presented for publication a paper entitled 'North American Bees—Descriptions and Synonyms.'

Wm. Trelease,
Secretary.

SCIENCE CLUB OF THE UNIVERSITY OF WISCONSIN.

At the regular meeting of the Club held March 11th the only paper of the evening was by Wm. B. Miller on 'Pulmonary Architecture.' The object of the paper was to show that in the structure of the lung there is a definite relation of the bronchi, blood and lymph vessels to each other; and that there is to be found in the lung the same as in the liver, intestines and other organs, a *unit* which repeats itself throughout the entire organ, and that when this unit is understood there is little difficulty in understanding the whole organ. The paper was illustrated by means of numerous models, macroscopic and microscopic preparations.

Wm. S. Marshall,
Secretary.